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OF THE

THIRTY-SEVENTH MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE;

HELD AT

DUNDEE IN SEPTEMBER 1867.

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OBJECTS AND RULES

OF

THE ASSOCIATION.

OBJECTS.

The Association contemplates no interference with the ground occupied by other institutions. Its objects are,—To give a stronger impulse and a more systematic direction to scientific inquiry,—to promote the intercourse of those who cultivate Science in different parts of the British Empire, with one another, and with foreign philosophers,—to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progress.

RULES.

ADMISSION OF MEMBERS AND ASSOCIATES.

All persons who have attended the first Meeting shall be entitled to become Members of the Association, upon subscribing an obligation to conform to its Rules.

The Fellows and Members of Chartered Literary and Philosophical Societies publishing Transactions, in the British Empire, shall be entitled, in like manner, to become Members of the Association.

The Officers and Members of the Councils, or Managing Committees, of Philosophical Institutions, shall be entitled, in like manner, to become Members of the Association.

All Members of a Philosophical Institution recommended by its Council or Managing Committee, shall be entitled, in like manner, to become Members of the Association.

Persons not belonging to such Institutions shall be elected by the General Committee or Council, to become Life Members of the Association, Annual Subscribers, or Associates for the year, subject to the approval of a General Meeting.

COMPOSITIONS, SUBSCRIPTIONS, AND PRIVILEGES.

Life Members shall pay, on admission, the sum of Ten Pounds. They shall receive *gratuitously* the Reports of the Association which may be published after the date of such payment. They are eligible to all the offices of the Association.

Annual Subscribers shall pay, on admission, the sum of Two Pounds, and in each following year the sum of One Pound. They shall receive *gratuitously* the Reports of the Association for the year of their admission and for the years in which they continue to pay *without intermission* their Annual Subscription. By omitting to pay this Subscription in any particular year, Members of this class (Annual Subscribers) *lose for that and all future years* the privilege of receiving the volumes of the Association *gratis*: but they may resume their Membership and other privileges at any subsequent Meeting of the Association, paying on each such occasion the sum of One Pound. They are eligible to all the Offices of the Association.

Associates for the year shall pay on admission the sum of One Pound. They shall not receive *gratuitously* the Reports of the Association, nor be eligible to serve on Committees, or to hold any office.

The Association consists of the following classes:—

1. Life Members admitted from 1831 to 1845 inclusive, who have paid on admission Five Pounds as a composition.

2. Life Members who in 1846, or in subsequent years, have paid on admission Ten Pounds as a composition.

3. Annual Members admitted from 1831 to 1839 inclusive, subject to the payment of One Pound annually. [May resume their Membership after intermission of Annual Payment.]

4. Annual Members admitted in any year since 1839, subject to the payment of Two Pounds for the first year, and One Pound in each following year. [May resume their Membership after intermission of Annual Payment.]

5. Associates for the year, subject to the payment of One Pound.

6. Corresponding Members nominated by the Council.

And the Members and Associates will be entitled to receive the annual volume of Reports, *gratis*, or to *purchase* it at reduced (or Members') price, according to the following specification, viz.:—

1. *Gratis.*—Old Life Members who have paid Five Pounds as a composition for Annual Payments, and previous to 1845 a further sum of Two Pounds as a Book Subscription, or, since 1845, a further sum of Five Pounds.

   New Life Members who have paid Ten Pounds as a composition.

   Annual Members who have not intermitted their Annual Subscription.

2. *At reduced or Members' Prices,* viz. two-thirds of the Publication Price.—Old Life Members who have paid Five Pounds as a composition for Annual Payments, but no further sum as a Book Subscription.

   Annual Members who have intermitted their Annual Subscription.

   Associates for the year. [Privilege confined to the volume for that year only.]

3. Members may purchase (for the purpose of completing their sets) any of the first seventeen volumes of Transactions of the Association, *and of which more than* 100 *copies remain,* at one-third of the Publication Price. Application to be made (by letter) to Messrs. Taylor & Francis, Red Lion Court, Fleet St., London.

Subscriptions shall be received by the Treasurer or Secretaries.

MEETINGS.

The Association shall meet annually, for one week, or longer. The place of each Meeting shall be appointed by the General Committee at the previous Meeting; and the Arrangements for it shall be entrusted to the Officers of the Association.

GENERAL COMMITTEE.

The General Committee shall sit during the week of the Meeting, or longer, to transact the business of the Association. It shall consist of the following persons:—

1. Presidents and Officers for the present and preceding years, with authors of Reports in the Transactions of the Association.

2. Members who have communicated any Paper to a Philosophical Society, which has been printed in its Transactions, and which relates to such subjects as are taken into consideration at the Sectional Meetings of the Association.

3. Office-bearers for the time being, or Delegates, altogether not exceeding three in number, from any Philosophical Society publishing Transactions.

4. Office-bearers for the time being, or Delegates, not exceeding three, from Philosophical Institutions established in the place of Meeting, or in any place where the Association has formerly met.

5. Foreigners and other individuals whose assistance is desired, and who are specially nominated in writing for the Meeting of the year by the President and General Secretaries.

6. The Presidents, Vice-Presidents, and Secretaries of the Sections are *ex-officio* members of the General Committee for the time being.

SECTIONAL COMMITTEES.

The General Committee shall appoint, at each Meeting, Committees, consisting severally of the Members most conversant with the several branches of Science, to advise together for the advancement thereof.

The Committees shall report what subjects of investigation they would particularly recommend to be prosecuted during the ensuing year, and brought under consideration at the next Meeting.

The Committees shall recommend Reports on the state and progress of particular Sciences, to be drawn up from time to time by competent persons, for the information of the Annual Meetings.

COMMITTEE OF RECOMMENDATIONS.

The General Committee shall appoint at each Meeting a Committee, which shall receive and consider the Recommendations of the Sectional Committees, and report to the General Committee the measures which they would advise to be adopted for the advancement of Science.

All Recommendations of Grants of Money, Requests for Special Researches, and Reports on Scientific Subjects, shall be submitted to the Committee of Recommendations, and not taken into consideration by the General Committee, unless previously recommended by the Committee of Recommendations.

LOCAL COMMITTEES.

Local Committees shall be formed by the Officers of the Association to assist in making arrangements for the Meetings.

Local Committees shall have the power of adding to their numbers those Members of the Association whose assistance they may desire.

OFFICERS.

A President, two or more Vice-Presidents, one or more Secretaries, and a Treasurer, shall be annually appointed by the General Committee.

COUNCIL.

In the intervals of the Meetings, the affairs of the Association shall be managed by a Council appointed by the General Committee. The Council may also assemble for the despatch of business during the week of the Meeting.

PAPERS AND COMMUNICATIONS.

The Author of any paper or communication shall be at liberty to reserve his right of property therein.

ACCOUNTS.

The Accounts of the Association shall be audited annually, by Auditors appointed by the Meeting.

Table showing the Places and Times of Meeting of the British Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Commencement.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The EARL FITZWILLIAM, D.C.L., F.R.S., F.G.S., &c. YORK, September 27, 1831.	Rev. W. Vernon Harcourt, M.A., F.R.S., F.G.S.	William Gray, jun., F.G.S. Professor Phillips, M.A., F.R.S., F.G.S.
The REV. W. BUCKLAND, D.D., F.R.S., F.G.S., &c. OXFORD, June 19, 1832.	Sir David Brewster, F.R.S. L. & E., &c. Rev. W. Whewell, F.R.S., Pres. Geol. Soc.	Professor Daubeny, M.D., F.R.S., &c. Rev. Professor Powell, M.A., F.R.S., &c.
The REV. ADAM SEDGWICK, M.A., V.P.R.S., V.P.G.S. CAMBRIDGE, June 25, 1833.	G. B. Airy, F.R.S., Astronomer Royal, &c. John Dalton, D.C.L., F.R.S.	Rev. Professor Henslow, M.A., F.L.S., F.G.S. Rev. W. Whewell, F.R.S.
SIR T. MACDOUGALL BRISBANE, K.C.B., D.C.L., F.R.S. L. & E. EDINBURGH, September 8, 1834.	Sir David Brewster, F.R.S., &c. Rev. T. R. Robinson, D.D.	Professor Forbes, F.R.S. L. & E., &c. Sir John Robinson, Sec. R.S.E.
The REV. PROVOST LLOYD, LL.D. DUBLIN, August 10, 1835.	Viscount Oxmantown, F.R.S., F.R.A.S. Rev. W. Whewell, F.R.S., &c.	Sir W. R Hamilton, Astron. Royal of Ireland, &c. Rev. Professor Lloyd, F.R.S.
The MARQUIS OF LANSDOWNE, D.C.L., F.R.S., &c. BRISTOL, August 22, 1836.	The Marquis of Northampton, FR.S. Rev. W. D. Conybeare, F.R.S., F.G.S. J. C. Prichard, M.D., F.R.S.	Professor Daubeny, M.D., F.R.S., &c. V. F. Hovenden, Esq.
The EARL OF BURLINGTON, F.R.S., F.G.S., Chancellor of the University of London LIVERPOOL, September 11, 1837.	The Bishop of Norwich, P.L.S., F.G.S. John Dalton, D.C.L., F.R.S. Sir Philip de Grey Egerton, Bart., F.R.S., F.G.S. Rev. W. Whewell, F.R.S.	Professor Traill, M.D. Wm. Wallace Currie, Esq. Joseph N. Walker, Pres. Royal Institution, Liverpool.
The DUKE OF NORTHUMBERLAND, F.R.S., F.G.S., &c. NEWCASTLE-ON-TYNE, August 20, 1838.	The Bishop of Durham, F.R.S., F.S.A. The Rev. W. Vernon Harcourt, F.R.S., &c. Prideaux John Selby, Esq., F.R.S.E.	John Adamson, F.L.S., &c. Wm. Hutton, F.G.S. Professor Johnston, M.A., F.R.S.
The REV. W. VERNON HARCOURT, M.A., F.R.S., &c. BIRMINGHAM, August 26, 1839.	Marquis of Northampton. Earl of Dartmouth. The Rev. T. R. Robinson, D.D. John Corrie, Esq., F.R.S. Very Rev. Principal Macfarlane	George Barker, Esq., F.R.S. Peyton Blakiston, M.D. Joseph Hodgson, Esq., F.R.S. Follett Osler, Esq.
The MARQUIS OF BREADALBANE, F.R.S. GLASGOW, September 17, 1840.	Major-General Lord Greenock, F.R.S.E. Sir David Brewster, F.R.S. Sir T. M. Brisbane, Bart., F.R.S. The Earl of Mount Edgecumbe	Andrew Liddell, Esq. Rev. J. P. Nicol, LL.D. John Strang, Esq.
The REV. PROFESSOR WHEWELL, F.R.S., &c PLYMOUTH, July 29, 1841.	The Earl of Morley. Lord Eliot, M.P. Sir C. Lemon, Bart. Sir D. T. Acland, Bart.	W. Snow Harris, Esq., F.R.S. Col. Hamilton Smith, F.L.S. Robert Were Fox, Esq. Richard Taylor, jun., Esq.
The LORD FRANCIS EGERTON, F.G.S. MANCHESTER, June 23, 1842.	John Dalton, D.C.L., F.R.S. Hon. and Rev. W. Herbert, F.L.S., &c. Rev. A. Sedgwick, M.A., F.R.S. W. C. Henry, M.D., F.R.S. Sir Benjamin Heywood, Bart.	Peter Clare, Esq., F.R.A.S. W. Fleming, M.D. James Heywood, Esq., F.R.S.
The EARL OF ROSSE, F.R.S. CORK, August 17, 1843.	Earl of Listowel. Viscount Adare Sir W. R. Hamilton, Pres.R.I.A. Rev. T. R. Robinson, D.D.	Professor John Stevelly, M.A. Rev. Jos. Carson, F.T.C. Dublin. William Keleher, Esq. Wm. Clear, Esq.

The REV. G. PEACOCK, D.D. (Dean of Ely), F.R.S. YORK, September 26, 1844.	Earl Fitzwilliam, F.R.S. Viscount Morpeth, F.G.S. The Hon. John Stuart Wortley, M.P. Sir David Brewster, K.H., F.R.S. Michael Faraday, Esq., D.C.L., F.R.S. Rev. W. V. Harcourt, F.R.S.	William Hatfeild, Esq., F.G.S. Thomas Meynell, Esq., F.L.S. Rev. W. Scoresby, LL.D., F.R.S. William West, Esq.
SIR JOHN F. W. HERSCHEL, Bart., F.R.S., &c. CAMBRIDGE, June 19, 1845.	The Earl of Hardwicke. The Bishop of Norwich Rev. J. Graham, D.D. Rev. G. Ainslie, D.D. G. B. Airy, Esq., M.A., D.C.L., F.R.S. The Rev. Professor Sedgwick, M.A., F.R.S.	William Hopkins, Esq., M.A., F.R.S. Professor Ansted, M.A., F.R.S.
SIR RODERICK IMPEY MURCHISON, G.C.St.S., F.R.S. SOUTHAMPTON, September 10, 1846.	The Marquis of Winchester. The Earl of Yarborough, D.C.L. Lord Ashburton, D.C.L. Viscount Palmerston, M.P. Right Hon. Charles Shaw Lefevre, M.P. Sir George T. Staunton, Bart., M.P., D.C.L., F.R.S. The Lord Bishop of Oxford, F.R.S. Professor Owen, M.D., F.R.S. Professor Powell, F.R.S.	Henry Clark, M.D. T. H. C. Moody, Esq.
SIR ROBERT HARRY INGLIS, Bart., D.C.L., F.R.S., M.P. for the University of Oxford OXFORD, June 23, 1847.	The Earl of Rosse, F.R.S. The Lord Bishop of Oxford, F.R.S. The Vice-Chancellor of the University Thomas G. Bucknall Estcourt, Esq., D.C.L., M.P. for the University of Oxford. Very Rev. the Dean of Westminster, D.D., F.R.S. Professor Daubeny, M.D., F.R.S. The Rev. Prof. Powell, M.A., F.R.S.	Rev. Robert Walker, M.A., F.R.S. H. Wentworth Acland, Esq., B.M.
The MARQUIS OF NORTHAMPTON, President of the Royal Society, &c. SWANSEA, August 9, 1848.	The Marquis of Bute, K.T. Viscount Adare, F.R.S. Sir H. T. DelaBeche, F.R.S., Pres. G.S. The Very Rev. the Dean of Llandaff, F.R.S. Lewis W. Dillwyn, Esq., F.R.S. W. R. Grove, Esq., F.R.S. J. H. Vivian, Esq., M.P., F.R.S. The Lord Bishop of St. David's.	Matthew Moggridge, Esq. D. Nicol, M.D.
The REV. T. R. ROBINSON, D.D., M.R.I.A., F.R.A.S. BIRMINGHAM, September 12, 1849.	The Earl of Harrowby. The Lord Wrottesley, F.R.S. Right Hon. Sir Robert Peel, Bart., M.P., D.C.L., F.R.S. Charles Darwin, Esq., M.A., F.R.S., Sec. G.S. Professor Faraday, D.C.L., F.R.S. Sir David Brewster, K.H., LL.D., F.R.S. Rev. Prof. Willis, M.A., F.R.S.	Captain Tindal, R.N. William Wills, Esq. Bell Fletcher, Esq., M.D. James Chance, Esq.
SIR DAVID BREWSTER, K.H., LL.D., F.R.S. L. & E., Principal of the United College of St. Salvator and St. Leonard, St. Andrew EDINBURGH, July 21, 1850.	Right Hon. the Lord Provost of Edinburgh The Earl of Cathcart, K.C.B., F.R.S.E. The Earl of Rosebery, K.T., D.C.L., F.R.S. Right Hon. David Boyle (Lord Justice-General), F.R.S.E. General Sir Thomas M. Brisbane, Bart., D.C.L., F.R.S., Pres. R.S.E. Very Rev. John Lee, D.D., V.P.R.S.E., Principal of the University of Edinburgh. Professor W. P. Alison, M.D., V.P.R.S.E. Professor J. D. Forbes, F.R.S., Sec. R.S.E.	Rev. Professor Kelland, M.A., F.R.S.L. & E. Professor Balfour, M.D., F.R.S.E., F.L.S. James Tod, Esq., F.R.S.E.
GEORGE BIDDELL AIRY, Esq., D.C.L., F.R.S., Astronomer Royal IPSWICH, July 2, 1851.	The Lord Rendlesham, M.P. The Lord Bishop of Norwich Rev. Professor Sedgwick, M.A., F.R.S. Rev. Professor Henslow, M.A., F.L.S. Sir John P. Boileau, Bart., F.R.S. Sir William F. F. Middleton, Bart. J. C. Cobbold, Esq., M.P. T. B. Western, Esq.	Charles May, Esq., F.R.A.S. Dillwyn Sims, Esq. George Arthur Biddell, Esq. George Ransome, Esq., F.L.S.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
COLONEL EDWARD SABINE, Royal Artillery, Treas. & V.P. of the Royal Society **Belfast**, September 1, 1852.	The Earl of Enniskillen, D.C.L. F.R.S. The Earl of Rosse, M.R.I.A., Pres. R.S. Sir Henry T. DelaBeche, F.R.S. Rev. Edward Hincks, D.D., M.R.I.A. Rev. P. S. Henry, D.D., Pres. Queen's College, Belfast Rev. T. R. Robinson, D.D., Pres. R.I.A., F.R.A.S. Professor G. G. Stokes, F.R.S. Professor Stevelly, LL.D.	W. J. C. Allen, Esq. William M'Gee, M.D. Professor W. P. Wilson.
WILLIAM HOPKINS, Esq., M.A., V.P.R.S., F.G.S., & Pres. Camb. Phil. Society **Hull**, September 7, 1853.	The Earl of Carlisle, F.R.S. Lord Londesborough, F.R.S. Professor Faraday, D.C.L., F.R.S. Rev. Prof. Sedgwick, M.A., F.R.S. Charles Frost, Esq., F.S.A., Pres. of the Hull Lit. and Philos. Society William Spence, Esq., F.R.S. Lieut.-Col. Sykes, F.R.S. Professor Wheatstone, F.R.S.	Henry Cooper, M.D., V.P. Hull. Lit. & Phil. Society. Bethel Jacobs, Esq., Pres. Hull Mechanics' Inst.
The EARL OF HARROWBY, F.R.S. **Liverpool**, September 20, 1854.	The Lord Wrottesley, M.A., F.R.S., F.R.A.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Professor Owen, M.D., LL.D., F.R.S., F.L.S., F.G.S. Rev. Professor Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., Master of Trinity College, Cambridge William Lassell, Esq., F.R.S.L. & E., F.R.A.S. Joseph Brooks Yates, F.S.A., F.R.G.S.	Joseph Dickinson, M.D., F.R.S. Thomas Inman, M.D.
The DUKE OF ARGYLL, F.R.S., F.G.S. **Glasgow**, September 12, 1855.	The Very Rev. Principal Macfarlane, D.D. Sir William Jardine, Bart., F.R.S.E. Sir Charles Lyell, M.A., LL.D., F.R.S. James Smith, Esq., F.R.S. L. & E. Walter Crum, Esq., F.R.S. Thomas Graham, Esq., M.A., F.R.S., Master of the Royal Mint Professor William Thomson, M.A., F.R.S.	John Strang, LL.D. Professor Thomas Anderson, M.D. William Gourlie, Esq.
CHARLES G. B. DAUBENY, M.D., LL.D., F.R.S., Professor of Botany in the University of Oxford **Cheltenham**, August 6, 1856.	The Earl of Ducie, F.R.S., F.G.S. The Lord Bishop of Gloucester and Bristol Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. Thomas Barwick Lloyd Baker, Esq. The Rev. Francis Close, M.A.	Capt. Robinson, R.A. Richard Beamish, Esq., F.R.S. John West Hugall, Esq.
The REV. HUMPHREY LLOYD, D.D., D.C.L., F.R.S. L. & E., V.P.R.I.A. **Dublin**, August 26, 1857.	The Right Honourable the Lord Mayor of Dublin The Provost of Trinity College, Dublin The Marquis of Kildare. Lord Talbot de Malahide The Lord Chancellor of Ireland The Lord Chief Baron, Dublin Sir William R. Hamilton, LL.D., F.R.A.S., Astronomer Royal of Ireland Lieut.-Colonel Larcom, R.E., LL.D., F.R.S. Richard Griffith, Esq., LL.D., M.R.I.A., F.R.S.E., F.G.S.	Lundy E. Foote, Esq. Rev. Professor Jellett, F.T.C.D. W. Neilson Hancock, LL.D.
RICHARD OWEN, M.D., D.C.L., V.P.R.S., F.L.S., F.G.S., Superintendent of the Natural-History Departments of the British Museum **Leeds**, September 22, 1858.	The Lord Monteagle, F.R.S. The Lord Viscount Goderich, M.P., F.R.G.S. The Right Hon. M. T. Baines, M.A., M.P. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. The Rev. W. Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., F.R.A.S., Master of Trinity College, Cambridge James Garth Marshall, Esq., M.A., F.G.S. R. Monckton Milnes, Esq., D.C.L., M.P., F.R.G.S.	Rev. Thomas Hincks, B.A. W. Sykes Ward, Esq., F.C.S. Thomas Wilson, Esq., M.A.

HIS ROYAL HIGHNESS THE PRINCE CONSORT ABERDEEN, September 14, 1859.	The Duke of Richmond, K.G., F.R.S. The Earl of Aberdeen, LL.D., K.G., K.T., F.R.S. The Lord Provost of the City of Aberdeen. Sir John F. W. Herschel, Bart., M.A., D.C.L., F.R.S. Sir David Brewster, K.H., D.C.L., F.R.S. Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. The Rev. W. V. Harcourt, M.A., F.R.S. The Rev. T. R. Robinson, D.D., F.R.S. A. Thomson, Esq., LL.D., F.R.S., Convener of the County of Aberdeen.	Professor J. Nicol, F.R.S.E., F.G.S. Professor Fuller, M.A. John F. White, Esq.
The LORD WROTTESLEY, M.A., V.P.R.S., F.R.A.S. OXFORD, June 27, 1860.	The Earl of Derby, K.G., P.C., D.C.L., Chancellor of the Univ. of Oxford The Rev. F. Jeune, D.C.L., Vice-Chancellor of the University of Oxford The Duke of Marlborough, D.C.L., F.G.S., Lord Lieutenant of Oxfordshire The Earl of Rosse, K.P., M.A., F.R.S., F.R.A.S. The Lord Bishop of Oxford, D.D., F.R.S. The Very Rev. H. G. Liddell, D.D., Dean of Christ Church, Oxford Professor Daubeny, M.D., LL.D., F.R.S., F.L.S., F.G.S. Professor Acland, M.D., F.R.S. Professor Donkin, M.A., F.R.S., F.R.A.S.	George Rolleston, M.D., F.L.S. H. J. S. Smith, Esq., M.A., F.C.S. George Griffith, Esq., M.A., F.C.S.
WILLIAM FAIRBAIRN, Esq., LL.D., C.E., F.R.S. MANCHESTER, September 4, 1861.	The Earl of Ellesmere, F.R.G.S. The Lord Stanley, M.P., D.C.L., F.R.G.S. The Lord Bishop of Manchester, D.D., F.R.S., F.G.S. Sir Philip de M. Grey Egerton, Bart., M.P., F.R.S., F.G.S. Sir Benjamin Heywood, Bart., F.R.S. Thomas Bazley, Esq., M.P. James Aspinall Turner, Esq., M.P. James Prescott Joule, Esq., LL.D., F.R.S., Pres. Lit. & Phil. Soc. Manchester. Professor E. Hodgkinson, F.R.S., M.R.I.A., M.I.C.E. Joseph Whitworth, Esq., F.R.S., M.I.C.E.	R. D. Darbishire, Esq., B.A., F.G.S. Alfred Neild, Esq. Arthur Ransome, M.A., Esq. Professor H. E. Roscoe, B.A.
The REV. R. WILLIS, M.A., F.R.S., Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge CAMBRIDGE, October 1, 1862.	The Rev. the Vice-Chancellor of the University of Cambridge The Very Rev. Harvey Goodwin, D.D., Dean of Ely. The Rev. W. Whewell, D.D., F.R.S., Master of Trinity College, Cambridge The Rev. Professor Sedgwick, M.A., D.C.L., F.R.S. Rev. J. Challis, M.A., F.R.S. G. B. Airy, Esq., M.A., D.C.L., F.R.S., Astronomer Royal Professor G. G. Stokes, M.A., D.C.L., Sec. R.S. Professor J. C. Adams, M.A., D.C.L., F.R.S., Pres. C.P.S.	Professor C. C. Babington, M.A., F.R.S., F.L.S. Professor G. D. Liveing, M.A. The Rev. N. M. Ferrers, M.A.
SIR W. ARMSTRONG, C.B., LL.D., F.R.S. NEWCASTLE-ON-TYNE, August 26, 1863.	Sir Walter C. Trevelyan, Bart., M.A. Sir Charles Lyell, LL.D., D.C.L., F.R.S., F.G.S. Hugh Taylor, Esq., Chairman of the Coal Trade Isaac Lowthian Bell, Esq., Mayor of Newcastle Nicholas Wood, Esq., President of the Northern Institute of Mining Engineers Rev. Temple Chevallier, B.D., F.R.A.S. William Fairbairn, Esq., LL.D., F.R.S.	A. Noble, Esq. Augustus H. Hunt, Esq. R. C. Clapham, Esq.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
SIR CHARLES LYELL, Bart., M.A., D.C.L., F.R.S. Bath, September 14, 1864.	The Right Hon. the Earl of Cork and Orrery, Lord Lieutenant of Somersetshire The Most Noble the Marquis of Bath The Right Hon. Earl Nelson The Right Hon. Lord Portman The Very Reverend the Dean of Hereford The Venerable the Archdeacon of Bath W. Tite, Esq., M.P., F.R.S., F.G.S., F.S.A. A. E. Way, Esq., M.P. Francis H. Dickinson, Esq. W. Sanders, Esq. F.R.S., F.G.S.	C. Moore, Esq., F.G.S. C. E. Davis, Esq. The Rev. H. H. Winwood, M.A.
JOHN PHILLIPS, Esq., M.A., LL.D., F.R.S., F.G.S., Professor of Geology in the University of Oxford. Birmingham, September 6, 1865.	The Right Hon. the Earl of Lichfield, Lord-Lieutenant of Staffordshire The Right Hon. the Earl of Dudley The Right Hon. Lord Leigh, Lord-Lieutenant of Warwickshire The Right Hon. Lord Lyttelton, Lord-Lieutenant of Worcestershire The Right Hon. Lord Wrottesley, M.A., D.C.L., F.R.S., F.R.A.S. The Right Reverend the Lord Bishop of Worcester The Right Hon. C. B. Adderley, M.P. William Scholefield, Esq., M.P. J. T. Chance, Esq. F. Osler, Esq., F.R.S. The Rev. Charles Evans, M.A.	William Mathews, Esq., jun., F.G.S. John Henry Chamberlain, Esq. The Rev. G. D. Boyle, M.A.
WILLIAM R. GROVE, Esq., Q.C., M.A., F.R.S. Nottingham, August 22, 1866.	His Grace the Duke of Devonshire, Lord-Lieutenant of Derbyshire His Grace the Duke of Rutland, Lord-Lieutenant of Leicestershire The Right Hon. Lord Belper, Lord-Lieutenant of Nottinghamshire The Right Hon. J. E. Denison, M.P. J. C. Webb, Esq., High-Sheriff of Nottinghamshire Thomas Graham, Esq., F.R.S., Master of the Mint Joseph Hooker, M.D., F.R.S., F.L.S. John Russell Hinds, Esq., F.R.S., F.R.A.S. T. Close, Esq.	Dr. Robertson. Edward J. Lowe, Esq., F.R.A.S., F.L.S. The Rev. J. F. M'Callan, M.A.
HIS GRACE THE DUKE OF BUCCLEUCH, K.G., D.C.L., F.R.S. Dundee, September 4, 1867.	The Right Hon. the Earl of Airlie, K.T. The Right Hon. the Lord Kinnaird, K.T. Sir John Ogilvy, Bart., M.P. Sir Roderick I. Murchison, Bart., K.C.B., LL.D., F.R.S., F.G.S., &c. Sir David Baxter, Bart. Sir David Brewster, D.C.L., F.R.S., Principal of the University of Edinburgh. James D. Forbes, LL.D., F.R.S., Principal of the United College of St. Salvator and St. Leonards, University of St. Andrews	J. Henderson, Esq., jun. John Austin Lake Gloag, Esq. Patrick Anderson, Esq.
JOSEPH DALTON HOOKER, M.D., D.C.L., F.R.S., F.L.S. Norwich, August 19, 1868.	The Right Hon. the Earl of Leicester, Lord-Lieutenant of Norfolk. Sir John Peter Boileau, Bart., F.R.S. The Rev. Adam Sedgwick, M.A., L.L.D., F.R.S., F.G.S., &c., Woodwardian Professor of Geology in the University of Cambridge. Sir John Lubbock, Bart., F.R.S., F.L.S., F.G.S. John Couch Adams, Esq., M.A., D.C.L., F.R.S., F.R.A.S., Lowndean Professor of Astronomy and Geometry in the University of Cambridge. Thomas Brightwell, Esq.	Dr. Dalrymple. Rev. Joseph Crompton, M.A. Rev. Canon Hinds Howell.

Presidents and Secretaries of the Sections of the Association.

MATHEMATICAL AND PHYSICAL SCIENCES.

COMMITTEE OF SCIENCES, I.—MATHEMATICS AND GENERAL PHYSICS.

Date and Place.	Presidents.	Secretaries.
1832. Oxford	Davies Gilbert, D.C L., F.R.S....	Rev. H. Coddington.
1833. Cambridge	Sir D. Brewster, F.R.S............	Prof. Forbes.
1834. Edinburgh	Rev. W. Whewell, F.R.S..........	Prof. Forbes, Prof. Lloyd.

SECTION A.—MATHEMATICS AND PHYSICS.

Date and Place.	Presidents.	Secretaries.
1835. Dublin	Rev. Dr. Robinson..	Prof. Sir W. R. Hamilton, Prof. Wheatstone.
1836. Bristol	Rev. William Whewell, F.R.S....	Prof. Forbes, W. S. Harris, F. W. Jerrard.
1837. Liverpool ...	Sir D. Brewster, F.R.S...	W. S. Harris, Rev. Prof. Powell, Prof. Stevelly.
1838. Newcastle...	Sir J. F. W. Herschel, Bart., F.R.S.	Rev. Prof. Chevallier, Major Sabine, Prof. Stevelly.
1839. Birmingham	Rev. Prof. Whewell, F.R.S.	J. D. Chance, W. Snow Harris, Prof. Stevelly.
1840. Glasgow ...	Prof. Forbes, F.R.S.	Rev. Dr. Forbes, Prof. Stevelly, Arch. Smith.
1841. Plymouth...	Rev. Prof. Lloyd, F.R.S.	Prof. Stevelly.
1842. Manchester	Very Rev. G. Peacock, D.D., F.R.S.	Prof. M'Culloch, Prof. Stevelly, Rev. W. Scoresby.
1843. Cork	Prof M'Culloch, M.R.I.A.	J. Nott, Prof. Stevelly.
1844. York	The Earl of Rosse, F.R.S..........	Rev. Wm. Hey, Prof. Stevelly.
1845. Cambridge..	The Very Rev. the Dean of Ely .	Rev. H. Goodwin, Prof. Stevelly, G. G. Stokes.
1846. Southampton	Sir John F. W. Herschel, Bart., F.R.S.	John Drew, Dr. Stevelly, G. G. Stokes.
1847. Oxford	Rev. Prof. Powell, M.A., F.R.S. .	Rev. H. Price, Prof. Stevelly, G. G. Stokes.
1848. Swansea	Lord Wrottesley, F.R.S.	Dr. Stevelly, G. G. Stokes.
1849. Birmingham	William Hopkins, F.R.S.........	Prof. Stevelly, G. G. Stokes, W. Ridout Wills.
1850. Edinburgh..	Prof. J. D. Forbes, F.R.S., Sec. R.S.E.	W. J. Macquorn Rankine, Prof. Smyth, Prof. Stevelly, Prof. G. G. Stokes.
1851. Ipswich......	Rev. W. Whewell, D.D., F.R.S., &c.	S. Jackson, W. J. Macquorn Rankine, Prof. Stevelly, Prof. G. G. Stokes.
1852. Belfast	Prof. W. Thomson, M.A., F.R.S. L. & E.	Prof. Dixon, W. J. Macquorn Rankine, Prof. Stevelly, J. Tyndall.
1853. Hull	The Dean of Ely, F.R.S.	B. Blaydes Haworth, J. D. Sollitt, Prof. Stevelly, J. Welsh.
1854. Liverpool...	Prof. G. G. Stokes, M.A., Sec. R.S.	J. Hartnup, H. G. Puckle, Prof. Stevelly, J. Tyndall, J. Welsh.

Date and place.	Presidents.	Secretaries.
1855. Glasgow ...	Rev. Prof. Kelland, M.A., F.R.S. L. & E.	Rev. Dr. Forbes, Prof. D. Gray, Prof. Tyndall.
1856. Cheltenham	Rev. R. Walker, M.A., F.R.S. ..	C. Brooke, Rev. T. A. Southwood, Prof. Stevelly, Rev. J. C. Turnbull.
1857. Dublin	Rev. T. R. Robinson, DD., F.R.S., M.R.I.A.	Prof. Curtis, Prof. Hennessy, P. A. Ninnis, W. J. Macquorn Rankine, Prof. Stevelly.
1858. Leeds	Rev. W. Whewell, D.D., V.P.R.S.	Rev. S. Earnshaw, J. P. Hennessy, Prof. Stevelly, H. J. S. Smith, Prof. Tyndall.
1859. Aberdeen ..	The Earl of Rosse, M.A., K.P., F.R.S.	J. P. Hennessy, Prof. Maxwell, H. J. Smith, Prof. Stevelly.
1860. Oxford	Rev. B. Price, M.A., F.R.S.	Rev. G. C. Bell, Rev. T. Rennison, Prof. Stevelly.
1861. Manchester.	G. B. Airy, M.A., D.C.L., F.R.S.	Prof. R B. Clifton, Prof. H. J. S. Smith, Prof. Stevelly.
1862. Cambridge .	Prof. G. G. Stokes, M.A., F.R.S.	Prof. R. B. Clifton, Prof. H. J. S. Smith, Prof. Stevelly.
1863. Newcastle	Prof. W. J. Macquorn Rankine, C.E., F.R.S.	Rev. N. Ferrers, Prof. Fuller, F. Jenkin, Prof. Stevelly, Rev. C. T. Whitley.
1864. Bath	Prof. Cayley, M.A., F.R.S., F.R.A.S.	Prof. Fuller, F. Jenkin, Rev. G. Buckle, Prof. Stevelly.
1865. Birmingham	W. Spottiswoode, M.A., F.R.S., F.R.A.S.	Rev. T. N. Hutchinson, F. Jenkin, G. S. Mathews, Prof. H. J. S. Smith, J. M. Wilson
1866. Nottingham	Prof. Wheatstone, D.C.L., F.R.S.	Fleeming Jenkin, Prof. H. J. S. Smith, Rev. S. N. Swann.
1867. Dundee......	Prof. Sir W. Thomson, D.C.L., F.R.S.	Rev. C. Buckle, Prof. G. C. Foster, Prof. Fuller, Prof. Swan.

CHEMICAL SCIENCE.

COMMITTEE OF SCIENCES, II.—CHEMISTRY, MINERALOGY.

1832. Oxford	John Dalton, D.C.L., F.R.S.......	James F. W. Johnston.
1833. Cambridge..	John Dalton, D.C.L., F.R.S... ...	Prof. Miller.
1834. Edinburgh .	Dr. Hope.........	Mr. Johnston, Dr. Christison.

SECTION B.—CHEMISTRY AND MINERALOGY.

1835. Dublin	Dr. T. Thomson, F.R.S.	Dr. Apjohn, Prof. Johnston.
1836. Bristol	Rev. Prof. Cumming.....	Dr. Apjohn, Dr. C. Henry, W. Herapath.
1837. Liverpool...	Michael Faraday, F.R.S.	Prof. Johnston, Prof. Miller, Dr. Reynolds.
1838. Newcastle...	Rev. William Whewell, F.R.S. ...	Prof. Miller, R. L. Pattinson, Thomas Richardson.
1839. Birmingham	Prof. T. Graham, F.R.S.	Golding Bird, M.D., Dr. J. B. Melson.
1840. Glasgow ...	Dr. Thomas Thomson, F.R.S. ...	Dr. R. D. Thomson, Dr. T. Clark, Dr. L. Playfair.
1841. Plymouth...	Dr. Daubeny, F.R.S.	J. Prideaux, Robert Hunt, W. M. Tweedy.
1842. Manchester.	John Dalton, D.C.L., F.R.S.......	Dr. L. Playfair, R. Hunt, J. Graham.
1843. Cork	Prof. Apjohn, M.R.I.A.	R. Hunt, Dr. Sweeny.
1844. York	Prof. T. Graham, F.R.S.	Dr. L. Playfair, E. Solly, T. H. Barker.
1845. Cambridge .	Rev. Prof. Cumming	R. Hunt, J. P. Joule, Prof. Miller. E. Solly.

Date and Place.	Presidents.	Secretaries.
1846. Southampton	Michael Faraday, D.C.L., F.R.S.	Dr. Miller, R. Hunt, W. Randall.
1847. Oxford	Rev. W. V. Harcourt, M.A., F.R.S.	B. C. Brodie, R. Hunt., Prof. Solly.
1848. Swansea ...	Richard Phillips, F.R.S.	T. H. Henry, R. Hunt, T. Williams.
1849. Birmingham	John Percy, M.D., F.R.S.........	R. Hunt, G. Shaw.
1850. Edinburgh .	Dr. Christison, V.P.R.S.E. . ..	Dr. Anderson, R. Hunt, Dr. Wilson.
1851. Ipswich ...	Prof. Thomas Graham, F.R.S. ...	T. J. Pearsall, W. S. Ward.
1852. Belfast	Thomas Andrews, M.D., F.R.S. .	Dr. Gladstone, Prof. Hodges, Prof. Ronalds.
1853. Hull	Prof. J. F. W. Johnston, M.A., F.R.S.	H. S. Blundell, Prof. R. Hunt, T. J. Pearsall.
1854. Liverpool ..	Prof. W. A. Miller, M.D., F.R.S.	Dr. Edwards, Dr. Gladstone, Dr. Price.
1855. Glasgow ...	Dr. Lyon Playfair, C.B., F.R.S. .	Prof. Frankland, Dr. H. E. Roscoe.
1856. Cheltenham	Prof. B. C. Brodie, F.R.S.	J. Horsley, P. J. Worsley, Prof. Voelcker.
1857. Dublin	Prof. Apjohn, M.D., F.R.S., M.R.I.A.	Dr. Davy, Dr. Gladstone, Prof. Sullivan.
1858. Leeds	Sir J. F. W. Herschel, Bart., D.C.L.	Dr. Gladstone, W. Odling, R. Reynolds.
1859. Aberdeen	Dr Lyon Playfair, C.B., F.R.S. .	J. S. Brazier, Dr. Gladstone, G. D. Liveing, Dr. Odling.
1860. Oxford ...	Prof. B. C. Brodie, M.A., F.R.S. .	A. Vernon Harcourt, G. D. Liveing, A. B. Northcote.
1861. Manchester .	Prof. W. A. Miller, M.D., F.R.S	A. Vernon Harcourt, G. D Liveing.
1862 Cambridge .	Prof. W. A. Miller, M.D., F.R.S.	H. W. Elphinstone, W. Odling, Prof. Roscoe.
1863. Newcastle...	Dr. Alex. W. Williamson, F.R.S.	Prof. Liveing, H. L. Pattinson, J. C. Stevenson.
1864. Bath	W. Odling, M.B., F.R.S., F.C.S.	A. V. Harcourt, Prof. Liveing, R. Biggs.
1865. Birmingham	Prof. W. A. Miller, M.D., V.P.R.S.	A. V. Harcourt, H. Adkins, Prof. Wanklyn, A. Winkler Wills.
1866. Nottingham	H. Bence Jones, M.D., F.R.S. ..	J. H. Atherton, Prof. Liveing, W. J. Russell, J. White.
1867. Dundee.....	Prof. T. Anderson, M.D., F.R.S.E.	A. Crum Brown, Prof. G. D. Liveing, W. J. Russell.

GEOLOGICAL (AND, UNTIL 1851, GEOGRAPHICAL) SCIENCE.

COMMITTEE OF SCIENCES, III.—GEOLOGY AND GEOGRAPHY.

1832. Oxford.. ...	R. I. Murchison, F.R.S.	John Taylor.
1833. Cambridge..	G. B. Greenough, F.R.S.	W. Lonsdale, John Phillips.
1834. Edinburgh..	Prof. Jameson	Prof. Phillips, T. Jameson Torrie, Rev. J. Yates.

SECTION C.—GEOLOGY AND GEOGRAPHY.

1835. Dublin	R. J. Griffith	Captain Portlock, T. J. Torrie.
1836. Bristol	Rev. Dr. Buckland, F.R.S.—*Geography*. R. I. Murchison, F.R.S.	William Sanders, S. Stutchbury, T. J. Torrie.
1837. Liverpool...	Rev. Prof. Sedgwick, F.R.S.—*Geography*. G. B. Greenough, F.R.S.	Captain Portlock, R. Hunter.—*Geography*. Captain H. M. Denham, R.N.
1838. Newcastle..	C. Lyell, F.R.S., V.P.G.S.—*Geography*. Lord Prudhope.	W. C. Trevelyan, Capt. Portlock.—*Geography*. Capt. Washington.
1839. Birmingham	Rev. Dr. Buckland, F.R.S.—*Geography*. G. B. Greenough, F.R.S.	George Lloyd, M.D., H. E. Strickland, Charles Darwin.

Date and Place.	Presidents.	Secretaries.
1840. Glasgow ...	Charles Lyell, F.R.S.—*Geography*. G. B. Greenough, F.R.S.	W. J. Hamilton, D. Milne, Hugh Murray, H. E. Strickland, John Scoular, M.D.
1841. Plymouth ..	H. T. De la Beche, F.R.S.	W. J. Hamilton, Edward Moore, M.D., R. Hutton.
1842. Manchester	R. I. Murchison, F.R.S.	E. W. Binney, R. Hutton, Dr. R. Lloyd, H. E. Strickland.
1843. Cork	Richard E. Griffith, F.R.S., M.R.I.A.	Francis M. Jennings, H. E. Strickland.
1844. York	Henry Warburton, M.P., Pres. Geol. Soc.	Prof. Ansted, E. H. Bunbury.
1845. Cambridge .	Rev. Prof. Sedgwick, M.A., F.R.S.	Rev. J. C. Cumming, A. C. Ramsay, Rev. W. Thorp
1846. Southampton	Leonard Horner, F.R.S.—*Geography*. G. B. Greenough, F.R.S.	Robert A. Austen, J. H. Norten, M.D., Prof. Oldham.—*Geography*. Dr. C. T. Beke.
1847. Oxford	Very Rev. Dr. Buckland, F.R.S.	Prof. Ansted, Prof. Oldham, A. C. Ramsay, J. Ruskin.
1848. Swansea ...	Sir H. T. De la Beche, C.B., F.R.S.	Starling Benson, Prof. Oldham, Prof. Ramsay.
1849. Birmingham	Sir Charles Lyell, F.R.S., F.G.S.	J. Beete Jukes, Prof. Oldham, Prof. A. C. Ramsay.
1850. Edinburgh *	Sir Roderick I. Murchison, F.R.S.	A. Keith Johnston, Hugh Miller, Professor Nicol.

SECTION C. (*continued.*)—GEOLOGY.

1851. Ipswich ...	William Hopkins, M.A., F.R.S...	C. J. F. Bunbury, G. W. Ormerod, Searles Wood.
1852. Belfast	Lieut.-Col. Portlock, R.E., F.R.S.	James Bryce, James MacAdam, Prof. M'Coy, Prof. Nicol.
1853. Hull	Prof. Sedgwick, F.R.S.	Prof. Harkness, William Lawton.
1854. Liverpool ..	Prof. Edward Forbes, F.R.S. ...	John Cunningham, Prof. Harkness, G. W. Ormerod, J. W. Woodall.
1855. Glasgow ...	Sir R. I. Murchison, F.R.S.	James Bryce, Prof. Harkness, Prof. Nicol.
1856. Cheltenham	Prof. A. C. Ramsay, F.R.S.	Rev. P. B. Brodie, Rev. R. Hepworth, Edward Hull, J. Scougall, T. Wright.
1857. Dublin......	The Lord Talbot de Malahide ...	Prof. Harkness, Gilbert Sanders, Robert H. Scott.
1858. Leeds	William Hopkins, M.A., LL.D., F.R.S.	Prof. Nicol, H. C. Sorby, E. W. Shaw.
1859. Aberdeen...	Sir Charles Lyell, LL.D., D.C.L., F.R.S.	Prof. Harkness, Rev. J. Longmuir, H. C. Sorby.
1860. Oxford......	Rev. Prof. Sedgwick, LL.D., F.R.S., F.G.S.	Prof. Harkness, Edward Hull, Capt. Woodall.
1861. Manchester	Sir R. I. Murchison, D.C.L., LL.D., F.R.S., &c.	Prof. Harkness, Edward Hull, T. Rupert Jones, G. W. Ormerod.
1862. Cambridge	J. Beete Jukes, M.A., F.R.S.......	Lucas Barrett, Prof. T. Rupert Jones, H. C. Sorby.
1863. Newcastle...	Prof. Warington, W. Smyth, F.R.S., F.G.S.	E. F. Boyd, John Daglish, H. C. Sorby, Thomas Sopwith.
1864. Bath	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	W. B. Dawkins, J. Johnston, H. C. Sorby, W. Pengelly.

* At the Meeting of the General Committee held in Edinburgh, it was agreed "That the subject of Geography be separated from Geology and combined with Ethnology, to constitute a separate Section, under the title of the "Geographical and Ethnological Section," for Presidents and Secretaries of which see page xxxi.

Date and place.	Presidents.	Secretaries.
1865. Birmingham	Sir R. I. Murchison, Bart., K.C.B.	Rev. P. B. Brodie, J. Jones, Rev. E. Myers, H. C. Sorby, W. Pengelly.
1866. Nottingham	Prof. A. C. Ramsay, LL.D., F.R.S.	R. Etheridge, W. Pengelly, T. Wilson, G. H. Wright.
1867. Dundee ...	Archibald Geikie, F.R.S., F.G.S.	Edward Hull, W. Pengelly, Henry Woodward.

BIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, IV.—ZOOLOGY, BOTANY, PHYSIOLOGY, ANATOMY.

1832. Oxford.....	Rev. P. B. Duncan, F.G.S.	Rev. Prof. J. S. Henslow.
1833. Cambridge*	Rev. W. L. P. Garnons, F.L.S....	C. C. Babington, D. Don.
1834. Edinburgh	Prof. Graham................	W. Yarrell, Prof. Burnett.

SECTION D.—ZOOLOGY AND BOTANY.

1835. Dublin......	Dr. Allman..........................	J. Curtis, Dr. Litton.
1836. Bristol......	Rev. Prof. Henslow	J. Curtis, Prof. Don, Dr. Riley, S. Rootsey.
1837. Liverpool...	W. S. MacLeay	C. C. Babington, Rev. L. Jenyns, W. Swainson.
1838. Newcastle	Sir W. Jardine, Bart...	J. E. Gray, Prof. Jones, R. Owen, Dr. Richardson.
1839. Birmingham	Prof. Owen, F.R.S......	E. Forbes, W. Ick, R. Patterson.
1840. Glasgow ...	Sir W. J. Hooker, LL.D.	Prof. W. Couper, E. Forbes, R. Patterson.
1841. Plymouth	John Richardson, M.D., F.R.S....	J. Couch, Dr. Lankester, R. Patterson.
1842. Manchester	Hon. and Very Rev. W. Herbert, LL.D., F.L.S.	Dr. Lankester, R. Patterson, J. A. Turner.
1843. Cork.........	William Thompson, F.L.S.	G. J. Allman, Dr. Lankester, R. Patterson.
1844. York	Very Rev. The Dean of Manchester	Prof. Allman, H. Goodsir, Dr. King, Dr. Lankester.
1845. Cambridge	Rev. Prof. Henslow, F.L.S.	Dr. Lankester, T. V. Wollaston.
1846. Southamptn	Sir J. Richardson, M.D., F.R.S...	Dr. Lankester, T. V. Wollaston, H. Wooldridge.
1847. Oxford......	H. E. Strickland, M.A., F.R.S....	Dr. Lankester, Dr. Melville, T. V. Wollaston.

SECTION D.—ZOOLOGY AND BOTANY, INCLUDING PHYSIOLOGY.

[For Anatomical and Physiological Subsections and the temporary Section E of Anatomy and Medicine, see pp. xxx, xxxi. For the Presidents and Secretaries see p. xxxi.]

1848. Swansea ...	L. W. Dillwyn, F.R.S.	Dr. R. Wilbraham Falconer, A. Henfrey, Dr. Lankester.
1849. Birmingham	William Spence, F.R.S.	Dr. Lankester, Dr. Russell.
1850. Edinburgh ..	Prof. Goodsir, F.R.S. L. & E. ...	Prof. J. H. Bennett, M.D., Dr. Lankester, Dr. Douglas Maclagan.
1851. Ipswich......	Rev. Prof. Henslow, M.A., F.R.S.	Prof. Allman, F. W. Johnston, Dr. E. Lankester.
1852. Belfast	W. Ogilby	Dr. Dickie, George C. Hyndman, Dr. Edwin Lankester.
1853. Hull	C. C. Babington, M.A., F.R.S....	Robert Harrison, Dr. E. Lankester.

* At this Meeting Physiology and Anatomy were made a separate Committee, for Presidents and Secretaries of which see p. xxx.

Date and Place.	Presidents.	Secretaries.
1854. Liverpool ...	Prof. Balfour, M.D., F.R.S.......	Isaac Byerley, Dr. E. Lankester.
1855. Glasgow ...	Rev. Dr. Fleeming, F.R.S.E. .	William Keddie, Dr. Lankester.
1856. Cheltenham.	Thomas Bell, F.R.S., Pres. L.S.	Dr. J. Abercrombie, Prof. Buckman, Dr. Lankester.
1857. Dublin	Prof. W. H. Harvey, M.D., F.R.S.	Prof. J. R. Kinahan, Dr. E. Lankester, Robert Patterson, Dr. W. E. Steele.
1858. Leeds.........	C. C. Babington, M.A., F.R.S. .	Henry Denny, Dr Heaton, Dr. E. Lankester, Dr. E. Perceval Wright.
1859. Aberdeen ...	Sir W. Jardine, Bart., F.R.S.E. .	Prof. Dickie, M.D, Dr. E. Lankester, Dr. Ogilvy.
1860. Oxford	Rev. Prof. Henslow, F.L.S. ...	W. S. Church, Dr. E Lankester, P. L. Sclater, Dr. E Perceval Wright.
1861. Manchester .	Prof. C. C. Babington, F.R.S. ..	Dr. T. Alcock, Dr. E. Lankester, Dr. P. L Sclater, Dr E. P. Wright.
1862. Cambridge ..	Prof. Huxley, F.R S.	Alfred Newton, Dr. E P. Wright.
1863. Newcastle ..	Prof. Balfour, M.D., F.R S... .	Dr. E. Charlton, A. Newton, Rev. H. B. Tristram, Dr. E. P. Wright.
1864. Bath	Dr. John E. Gray, F.R.S. .	H. B. Brady, C. E Broom, H. T. Stainton, Dr. E. P Wright
1865. Birmingham	T. Thomson, M.D., F.R.S. ..	Dr. J. Anthony, Rev. C. Clarke, Rev. H. B. Tristram, Dr. E. P. Wright.

SECTION D.—BIOLOGY*.

1866. Nottingham.	Prof. Huxley, LL D, F.R S.—*Physiological Dep.* Prof. Humphry, M.D., F.R.S.—*Anthropological Dep.* Alfred R. Wallace, F.R.G.S.	Dr. J. Beddard, W. Felkin, Rev. H. B. Tristram, W. Turner, E. B. Tylor, Dr. E. P. Wright
1867. Dundee	Prof. Sharpey, M.D., Sec. R S —*Dep. of Zool. and Bot.* George Busk, M.D., F.R.S.	C. Spence Bate, Dr S. Cobbold, Dr. M. Foster, H. T. Stainton, Rev. H. B. Tristram, Prof. W. Turner.

ANATOMICAL AND PHYSIOLOGICAL SCIENCES.

COMMITTEES OF SCIENCES, V.—ANATOMY AND PHYSIOLOGY.

1833. Cambridge .	Dr. Haviland	Dr. Bond, Mr. Paget.
1834. Edinburgh ..	Dr. Abercrombie	Dr. Roget, Dr. William Thomson.

SECTION E. (UNTIL 1847.)—ANATOMY AND MEDICINE.

1835. Dublin	Dr. Pritchard......	Dr. Harrison, Dr. Hart.
1836. Bristol	Dr. Roget, F.R.S.	Dr. Symonds.
1837. Liverpool ...	Prof. W. Clark, M.D.	Dr. J. Carson, jun., James Long, Dr. J. R. W. Vose.
1838. Newcastle ...	T. E. Headlam, M.D.	T. M. Greenhow, Dr. J. R. W. Vose.
1839. Birmingham	John Yelloly, M.D., F.R.S.	Dr. G. O. Rees, F. Ryland.
1840. Glasgow ..	James Watson, M.D.........	Dr. J. Brown, Prof. Couper, Prof. Reid.
1841. Plymouth ...	P. M. Roget, M.D., Sec. R.S. .	Dr. J. Butter, J. Fuge, Dr. R. S. Sargent.
1842. Manchester .	Edward Holme, M.D., F.L.S. ...	Dr. Chaytor, Dr. Sargent.
1843. Cork	Sir James Pitcairn, M.D..	Dr. John Popham, Dr. R. S. Sargent.
1844. York	J. C. Pritchard, M.D.	I. Erichsen, Dr. R. S. Sargent.

* At the Meeting of the General Committee at Birmingham, it was resolved:—"That the title of Section D be changed to Biology;" and "That for the word 'Subsection' in the third paragraph of the business of the Sections, the word 'Department' be substituted."

Date and Place.	Presidents.	Secretaries.
	SECTION E.—PHYSIOLOGY.	
1845. Cambridge ..	Prof. J. Haviland, M.D.	Dr. R. S. Sargent, Dr. Webster.
1846. Southampton	Prof. Owen, M.D., F.R.S.	C. P. Keele, Dr. Laycock, Dr. Sargent.
1847. Oxford*.. ..	Prof. Ogle, M.D., F.R.S.	Dr. Thomas, K. Chambers, W. P. Ormerod.
	PHYSIOLOGICAL SUBSECTIONS.	
1850. Edinburgh ..	Prof. Bennett, M.D., F.R.S.E. ...	
1855. Glasgow ..	Prof. Allen Thomson, F.R.S. ..	Prof. J. H. Corbett, Dr. J. Struthers.
1857. Dublin	Prof. R. Harrison, M D.	Dr. R. D. Lyons, Prof. Redfern.
1858. Leeds...	Sir Benjamin Brodie, Bart., F.R.S	C. G. Wheelhouse.
1859. Aberdeen ...	Prof. Sharpey, M.D., Sec. R.S.	Prof. Bennett, Prof. Redfern.
1860. Oxford	Prof. G. Rolleston, M.D., F.L.S.	Dr. R M'Donnell, Dr. Edward Smith.
1861. Manchester .	Dr. John Davy, F.R.S.L. & E...	Dr. W. Roberts, Dr. Edward Smith.
1862. Cambridge ..	C. E. Paget, M.D.	G. F. Helm, Dr. Edward Smith.
1863. Newcastle .	Prof. Rolleston, M.D., F R.S.	Dr. D. Embleton, Dr. W. Turner.
1864. Bath	Dr. Edward Smith, LL.D., F.R.S.	J. S. Bartrum, Dr. W. Turner.
1865 Birmingham	Prof. Acland, M.D., LL.D., F.R.S	Dr. A. Fleming, Dr. P. Heslop, Oliver Pembleton, Dr. W. Turner.

GEOGRAPHICAL AND ETHNOLOGICAL SCIENCES.

[For Presidents and Secretaries previous to 1851, see Section C, p. xxvii.]

	ETHNOLOGICAL SUBSECTIONS.	
1846. Southampton	Dr. Pritchard	Dr. King.
1847. Oxford ...	Prof. H. H. Wilson, M.A.	Prof. Buckley.
1848. Swansea . .	. . . .	G. Grant Francis.
1849. Birmingham	. . ..	Dr. R. G. Latham.
1850. Glasgow .	Vice-Admiral Sir A. Malcolm ...	Daniel Wilson.
	SECTION E.—GEOGRAPHY AND ETHNOLOGY.	
1851. Ipswich	Sir R. I. Murchison, F.R.S., Pres. R.G.S.	R. Cull, Rev. J. W. Donaldson, Dr. Norton Shaw.
1852. Belfast	Col. Chesney, R.A., D.C.L., F.R.S.	R. Cull, R. MacAdam, Dr. Norton Shaw.
1853. Hull	R. G. Latham, M.D., F.R.S. . .	R. Cull, Rev. H. W. Kemp, Dr. Norton Shaw.
1854. Liverpool ...	Sir R. I. Murchison, D.C.L., F.R.S.	Richard Cull, Rev. H. Higgins, Dr. Ihne, Dr. Norton Shaw.
1855. Glasgow ...	Sir J. Richardson, M.D., F.R.S.	Dr. W. G. Blackie, R. Cull, Dr. Norton Shaw.
1856. Cheltenham.	Col. Sir H. C. Rawlinson, K.C.B.	R. Cull, F. D. Hartland, W. H. Rumsey, Dr. Norton Shaw.
1857. Dublin	Rev. Dr. J. Henthawn Todd, Pres. R.I.A.	R. Cull, S. Ferguson, Dr. R. R. Madden, Dr. Norton Shaw.
1858. Leeds.........	Sir R. I. Murchison, G.C.St.S., F.R.S.	R. Cull, Francis Galton, P. O'Callaghan, Dr. Norton Shaw, Thomas Wright.

* By direction of the General Committee at Oxford, Sections D and E were incorporated under the name of "Section D—Zoology and Botany, including Physiology" (see p. xxix). Section being then vacant was assigned in 1851 to Geography.

Date and Place.	Presidents.	Secretaries.
1859. Aberdeen ...	Rear-Admiral Sir James Clerk Ross, D.C.L., F.R.S.	Richard Cull, Professor Geddes, Dr. Norton Shaw.
1860. Oxford	Sir R. I. Murchison, D.C.L., F.R.S.	Capt. Burrows, Dr. J. Hunt, Dr. C. Lempriere, Dr. Norton Shaw.
1861. Manchester .	John Crawfurd, F.R.S.	Dr. J. Hunt, J. Kingsley, Dr. Norton Shaw, W. Spottiswoode.
1862. Cambridge ..	Francis Galton, F.R.S.	J. W. Clarke, Rev. J. Glover, Dr. Hunt, Dr. Norton Shaw, T. Wright.
1863. Newcastle ...	Sir R. I. Murchison, K.C.B., F.R.S.	C. Carter Blake, Hume Greenfield, C. R. Markham, R. S. Watson.
1864. Bath	Sir R. I. Murchison, K.C.B., F.R.S.	H. W. Bates, C. R. Markham, Capt. R. M. Murchison, T. Wright.
1865. Birmingham	Major-General Sir R. Rawlinson, M.P., K.C.B., F.R.S.	H. W. Bates, S. Evans, G. Jabet, C. R. Markham, Thomas Wright.
1866. Nottingham.	Sir Charles Nicholson, Bart., LL.D.	H. W. Bates, Rev. E. T. Cusins, R. H. Major, Clements R. Markham, D. W. Nash, T. Wright.
1867. Dundee......	Sir Samuel Baker, F.R.G.S.......	H. W. Bates, Cyril Graham, C. R. Markham, S. J. Mackie, R. Sturrock.

STATISTICAL SCIENCE.

COMMITTEES OF SCIENCES, VI.—STATISTICS.

1833. Cambridge .	Prof. Babbage, F.R.S.	J. E. Drinkwater.
1834. Edinburgh .	Sir Charles Lemon, Bart.	Dr. Cleland, C. Hope Maclean.

SECTION F.—STATISTICS.

1835. Dublin	Charles Babbage, F.R.S.	W. Greg, Prof. Longfield.
1836. Bristol	Sir Charles Lemon, Bart., F.R.S.	Rev. J. E. Bromby, C. B. Fripp, James Heywood.
1837. Liverpool ...	Rt. Hon. Lord Sandon	W. R. Greg, W. Langton, Dr. W. C. Tayler.
1838. Newcastle ...	Colonel Sykes, F.R.S.	W. Cargill, J. Heywood, W. R. Wood.
1839. Birmingham	Henry Hallam, F.R.S.	F. Clarke, R. W Rawson, Dr. W. C. Tayler.
1840. Glasgow ...	Rt. Hon. Lord Sandon, F.R.S., M.P.	C. R. Baird, Prof. Ramsay, R. W. Rawson.
1841. Plymouth ...	Lieut.-Col. Sykes, F.R.S.	Rev. Dr. Byrth, Rev. R. Luney, R. W. Rawson.
1842. Manchester .	G. W. Wood, M.P., F.L.S.	Rev. R. Luney, G. W. Ormerod, Dr. W. C. Tayler.
1843. Cork	Sir C. Lemon, Bart., M.P.	Dr. D. Bullen, Dr. W. Cooke Tayler.
1844. York	Lieut.-Col. Sykes, F.R.S., F.L.S.	J. Fletcher, J. Heywood, Dr. Laycock.
1845. Cambridge ..	Rt. Hon. The Earl Fitzwilliam..	J. Fletcher, W. Cooke Tayler, LL.D.
1846. Southampton	G. R. Porter, F.R.S.	J. Fletcher, F. G. P. Neison, Dr. W. C. Tayler, Rev. T. L. Shapcott.
1847. Oxford	Travers Twiss, D.C.L., F.R.S. ...	Rev. W. H. Cox, J. J. Danson, F. G. P. Neison.
1848. Swansea ...	J. H. Vivian, M.P., F.R.S.	J. Fletcher, Capt. R. Shortrede.
1849. Birmingham	Rt. Hon. Lord Lyttelton	Dr. Finch, Prof. Hancock, F. G. P. Neison.
1850. Edinburgh ..	Very Rev. Dr. John Lee, V.P.R.S.E.	Prof. Hancock, J. Fletcher, Dr. J. Stark.
1851. Ipswich.....	Sir John P. Boileau, Bart.	J. Fletcher, Prof. Hancock.
1852. Belfast	His Grace the Archbishop of Dublin.	Prof. Hancock, Prof. Ingram, James MacAdam, Jun.
1853. Hull	James Heywood, M.P., F.R.S....	Edward Cheshire, William Newmarch.

Date and Place.	President.	Secretaries.
1854. Liverpool ..	Thomas Tooke, F.R.S.	E. Cheshire, J. T. Danson, Dr. W. H. Duncan, W. Newmarch.
1855. Glasgow	R. Monckton Miles, M.P...	J. A. Campbell, E. Cheshire, W. Newmarch, Prof. R. H. Walsh.

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

1856. Cheltenham	Rt. Hon. Lord Stanley, M.P. ..	Rev. C. H. Bromby, E. Cheshire, Dr. W. N. Hancock Newmarch, W. M. Tartt.
1857. Dublin	His Grace the Archbishop of Dublin, M.R.I A.	Prof. Cairns, Dr. H. D. Hutton, W. Newmarch.
1858. Leeds.	Edward Baines	T. B. Baines, Prof. Cairns, S. Brown, Capt. Fishbourne, Dr. J. Strang.
1859. Aberdeen .	Col. Sykes, M.P., F.R S	Prof. Cairns, Edmund Macrory, A. M. Smith, Dr. John Strang.
1860. Oxford	Nassau W. Senior, M.A.	Edmund Macrory, W. Newmarch, Rev. Prof. J. E T. Rogers.
1861. Manchester	William Newmarch, F.R.S. .. .	David Chadwick, Prof. R. C. Christie, E. Macrory, Rev. Prof. J. E. T. Rogers
1862. Cambridge..	Edwin Chadwick, C.B	H. D. Macleod, Edmund Macrory.
1863. Newcastle .	William Tite, M.P., F.R.S. .	T Doubleday, Edmund Macrory, Frederick Purdy, James Potts.
1864. Bath..........	William Farr, M.D., D C.L, F.R.S.	E. Macrory, E. T. Payne, F. Purdy.
1865. Birmingham	Rt. Hon. Lord Stanley, LL.D, M P.	G J. D. Goodman, G. J. Johnston, E Macrory.
1866. Nottingham	Prof J. E T. Rogers ...	R Birkin, Jun., Prof. Leone Levi, E. Macrory.
1867. Dundee.. ..	M E. Grant Duff, M.P.	Prof Leone Levi, E. Macrory, A. J. Warden.

MECHANICAL SCIENCE.

SECTION G.—MECHANICAL SCIENCE.

1836. Bristol	Davies Gilbert, D C.L., F.R S..	T. G. Bunt, G. T. Clark, W. West.
1837. Liverpool ..	Rev. Dr. Robinson	Charles Vignoles, Thomas Webster.
1838. Newcastle ..	Charles Babbage, F.R.S.	R. Hawthorn, C. Vignoles, T. Webster.
1839. Birmingham	Prof. Willis, F.R.S, and Robert Stephenson.	W. Carpmael, William Hawkes, Thomas Webster.
1840. Glasgow ...	Sir John Robinson.	J. Scott Russell, J. Thomson, J. Tod, C. Vignoles.
1841. Plymouth .	John Taylor, F.R.S.	Henry Chatfield, Thomas Webster.
1842. Manchester .	Rev. Prof. Willis, F.R.S.	J. F. Bateman, J. Scott Russell, J. Thomson, Charles Vignoles.
1843. Cork	Prof. J. Macneill, M.R.I.A.. ...	James Thomson, Robert Mallet.
1844. York	John Taylor, F.R.S.	Charles Vignoles, Thomas Webster.
1845. Cambridge ..	George Rennie, F.R.S.	Rev. W. T. Kingsley.
1846. Southampton	Rev. Prof. Willis, M.A., F.R S. .	William Betts, Jun., Charles Manby.
1847. Oxford	Rev. Prof. Walker, M.A., F.R.S.	J. Glynn, R. A. Le Mesurier.
1848. Swansea......	Rev. Prof. Walker, M.A., F.R.S.	R. A. Le Mesurier, W. P. Struvé.
1849. Birmingham	Robert Stephenson, M.P., F.R.S.	Charles Manby, W. P. Marshall.
1850. Edinburgh ..	Rev. Dr. Robinson........	Dr. Lees, David Stevenson.
1851. Ipswich......	William Cubitt, F.R.S.	John Head, Charles Manby.
1852. Belfast	John Walker, C.E., LL.D., F.R.S.	John F. Bateman, C. B. Hancock, Charles Manby, James Thomson.

Date and Place.	President.	Secretaries.
1853. Hull	William Fairbairn, C.E., F.R.S.	James Oldham, J. Thomson, W. Sykes Ward.
1854. Liverpool ...	John Scott Russell, F.R.S.........	John Grantham, J. Oldham, J. Thomson.
1855. Glasgow ...	W. J. Macquorn Rankine, C.E., F.R.S.	L. Hill, Jun., William Ramsay, J. Thomson.
1856. Cheltenham	George Rennie, F.R.S.	C. Atherton, B. Jones, Jun., H. M. Jeffery.
1857. Dublin	The Right Hon. The Earl of Rosse, F.R.S.	Prof. Downing, W. T. Doyne, A. Tate, James Thomson, Henry Wright.
1858. Leeds.........	William Fairbairn, F.R.S..........	J. C. Dennis, J. Dixon, H. Wright.
1859. Aberdeen ...	Rev. Prof. Willis, M.A., F.R.S. .	R. Abernethy, P. Le Neve Foster, H. Wright.
1860. Oxford	Prof. W. J. Macquorn Rankine LL.D., F.R.S.	P. Le Neve Foster, Rev. F. Harrison, Henry Wright.
1861. Manchester .	J. F. Bateman, C.E., F.R.S......	P. Le Neve Foster, John Robinson, H. Wright.
1862. Cambridge ..	William Fairbairn, LL.D., F.R.S	W. M. Fawcett, P. Le Neve Foster.
1863. Newcastle ...	Rev. Prof. Willis, M.A., F.R.S. .	P. Le Neve Foster, P. Westmacott, J. F. Spencer.
1864. Bath	J. Hawkshaw, F.R.S.........	P. Le Neve Foster, Robert Pitt.
1865. Birmingham	Sir W. G. Armstrong, LL.D., F.R.S.	P. Le Neve Foster, Henry Lea, W. P. Marshall, Walter May.
1866. Nottingham	Thomas Hawksley, V.P.Inst. C.E., F.G.S.	P. Le Neve Foster, J. F. Iselin, M. A. Tarbottom.
1867. Dundee	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, John P. Smith, W. W. Urquhart.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THE GENERAL TREASURER'S ACCOUNT from August 22, 1866 (commencement of NOTTINGHAM MEETING) to September 4, 1867 (DUNDEE).

RECEIPTS.

				£	s.	d.
To Balance brought from last Account				503	10	2
Received for Life Compositions at Nottingham Meeting and since				340	0	0
„ Annual Subscriptions, ditto ditto				593	0	0
„ Associates' Tickets, ditto ditto				960	0	0
„ Ladies' Tickets, ditto ditto				771	0	0
„ Book Composition				5	0	0
„ Dividends on Stock, 1 year				250	15	0
„ Sale of Publications—viz.						
Reports	28	2	8			
Index, Catalogue of Stars, &c.	16	8	9			
				44	11	5
				£3467	61	7

P. L. SCLATER,
WM. ODLING,
J. GWYN JEFFREYS,
} *Auditors.*

PAYMENTS.

				£	s.	d.
By paid Expenses of Nottingham Meeting, also Sundry Printing, Binding, Advertising, and Incidental Petty Expenses				332	19	10
Paid for Printing, Engraving, and Binding Report of 35th Meeting (Birmingham)				731	2	4
For Salaries (1 year)				350	0	0
Paid on account of Grants made at Nottingham Meeting, viz.—						
For Maintaining Establishment of Kew Observatory	£600	0	0			
Meteorological Instruments, Palestine	50	0	0			
Lunar Committee	120	0	0			
Metrical Committee	30	0	0			
Committee on Kent's Hole Explorations	100	0	0			
„ Palestine Explorations	50	0	0			
„ Insect Fauna, Palestine	30	0	0			
„ British Rainfall	50	0	0			
„ Kilkenny Coal Fields	25	0	0			
„ Alum Bay Fossil Leaf Bed	25	0	0			
„ Luminous Meteors	50	0	0			
„ Bournemouth, &c. Leaf Beds	30	0	0			
„ Dredging, Shetland	75	0	0			
„ Steam-ship Reports Condensation	100	0	0			
„ Electrical Standards	100	0	0			
„ Ethyle and Methyle series	25	0	0			
„ Fossil Crustacea	25	0	0			
„ Sound under Water	24	4	0			
„ North Greenland Fauna	75	0	0			
„ Do. Plant Beds	100	0	0			
„ Iron and Steel Manufacture	25	0	0			
„ Patent Laws	30	0	0			
				1739	4	0
Balance at London and Westminster Bank	£314	4	5			
„ in hands of General Treasurer	0	6	0			
				314	10	5
				£3467	16	7

W. SPOTTISWOODE,
4 Sept. 1867.

OFFICERS AND COUNCIL, 1867-68.

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Wheatstone, Professor, F R.S
Williamson, Prof. A. W., F.R S.

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Francis Galton, Esq., M A, F.R.S, F R.G S, 42 Rutland Gate, Knightsbridge, London.
T Archer Hirst, Esq, F.R.S., F.R.A S., Professor of Mathematics in University College, London.

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William Spottiswoode, Esq., M A, F.R.S, F.R.G.S., 50 Grosvenor Place, London, S.W.

AUDITORS.

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President.—Professor Sir W. Thomson, D.C.L., F.R.S., &c.

Vice-Presidents.—Professor Fischer, F.R.S.; J. P. Gassiot, F.R.S.; Professor Kelland, F.R.S.; J. Clerk Maxwell, F.R.S.; Rev. C. Pritchard, F.R.S., Pres. Astr. Soc.; Professor Tyndall, LL.D., F.R.S.; Charles Wheatstone, D.C.L., F.R.S.

Secretaries.—Rev. G. Buckle, M.A.; Professor G. C. Foster; Professor Fuller, M.A.; Professor Swan.

SECTION B.—CHEMISTRY AND MINERALOGY, INCLUDING THEIR APPLICATIONS TO AGRICULTURE AND THE ARTS.

President.—Professor Thomas Anderson, M.D., F.R.S.E.

Vice-Presidents.—I. Lowthian Bell; Dr. J. H. Gilbert, F.R.S.; Professor Odling, F.R.S.; Professor Penny; Dr. Maxwell Simpson, F.R.S.; Professor Williamson, F.R.S.

Secretaries.—Dr. A. Crum Brown; Professor G. D. Liveing, F.C.S.; Dr. W. J. Russell.

SECTION C.—GEOLOGY.

President.—Archibald Geikie, F.R.S., F.R.S.E., F.G.S.

Vice-Presidents.—The Earl of Enniskillen, F.R.S.; Sir Philip Egerton, Bart., M.P., F.R.S.; Professor Harkness, F.R.S.; Dr. T. Oldham, F.R.S.; Professor Ramsay, F.R.S.

Secretaries.—Edward Hull, F.R.S., F.G.S.; W. Pengelly, F.R.S.; Henry Woodward, F.G.S., F.Z.S.

SECTION D.—BIOLOGY.

President.—Professor Sharpey, M.D., Sec. R.S.

Vice-Presidents.—Professor Allman, F.R.S.; Professor Balfour, F.R.S.; G. Busk, F.R.S.; Professor Christison, D.C.L.; Dr. J. Davy, F.R.S.; J. Gwyn Jeffreys, F.R.S.; Sir John Lubbock, Bart., F.R.S.; Professor Allen Thomson, F.R.S.; A. R. Wallace, F.R.G.S.

Secretaries.—C. Spence Bate, F.R.S.; Dr. Spencer Cobbold, F.R.S.; Dr. M. Foster; H. T. Stainton, F.R.S.; Rev. H. B. Tristram, M.A., F.L.S.; Professor W. Turner, F.R.S.E.

SECTION E.—GEOGRAPHY AND ETHNOLOGY.

President.—Sir Samuel Baker, F.R.G.S.

Vice-Presidents.—Sir James E. Alexander, K.C.L.S.; Admiral Sir Edward Belcher, K.C.B.; John Crawfurd, F.R.S.; Colonel Sir Henry James, R.E., F.R.S.; Sir John Lubbock, Bart., F.R.S.; Sir Roderick I. Murchison, Bart., K.C.B., F.R.S.; Admiral E. Ommanney, C.B.; Major-General Sir A. S. Waugh, F.R.S.

Secretaries.—H. W. Bates, Assist. Sec. R.G.S.; Cyril C. Graham, F.R.G.S.; Clements R. Markham, F.R.G.S.; S. J. Mackie, F.G.S.; R. Sturrock.

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

President.—M. E. Grant Duff, M.P.

Vice-Presidents.—Sir John Bowring, F.R.S.; Dr. Farr, F.R.S.; Professor Rogers; Colonel Sykes, M.P., F.R.S.; Principal Tulloch.

Secretaries.—Professor Leone Levi, F.S.A.; Edmund Macrory, M.A.; Alex. J. Warden.

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Report of the Council of the British Association, presented to the General Committee, Wednesday, September 4, 1867.

The Annual Reports of the Treasurer, the Parliamentary Committee, and the Kew Committee have been received, and will be presented to the General Committee.

At the last Meeting of the General Committee at Nottingham, the following Resolution was adopted:—

"That the Kew Committee be authorized to discuss and make the necessary arrangements with the Board of Trade should any proposal be made respecting the superintendence, reduction, and publication of Meteorological Observations, in accordance with the recommendations of the Report of the Committee appointed to consider certain questions relating to the Meteorological Department of the Board of Trade."

The arrangements which have been made by virtue of the power thus granted to the Kew Committee are described in detail in their Report, to which the Council beg to refer the General Committee.

The General Officers of the Association were requested by the Council to inquire into the practicability of having lectures delivered to the Operative Classes when the Association meets in large towns. The Officers having reported in favour of the occasional delivery of such lectures, and having likewise ascertained that a lecture of the kind was desired by the Local Officers at Dundee, the Council have requested Professor Tyndall to deliver one on Thursday next.

At the last Meeting of the Association, the Committee of Recommendations referred to the Council certain Resolutions which had been adopted by the Committees of two Sections, relative to the teaching of Natural Science in Schools. The Council, fully impressed with the importance of the subject, appointed a Special Committee for the purpose of inquiring into the question, and of preparing a report thereon. This Committee consisted of the General Officers of the Association, the Trustees, the Rev. F. W. Farrar, M.A., F.R.S., the Rev. T. N. Hutchinson, M.A., Professor Huxley, F.R.S., Mr. Payne, Professor Tyndall, F.R.S., and Mr. J. M. Wilson, M.A. The Council, having considered the Report presented by this Committee, adopted the recommendations contained therein, and resolved that the Report be submitted to the General Committee at Dundee.

The Council recommend that Sir Roderick Murchison, Bart., be elected a Vice-President at the present Meeting.

At their Meeting on the 9th of March, the Council also decided to recommend for election, as a Vice-President, the late Provost Parker. They afterwards learned, with deep regret, that death had deprived the Association of the services of so esteemed and zealous an officer.

The name of M. Janssen has been added to the list of Corresponding Members.

The Council have been informed that the Association will be invited to hold future Meetings at Norwich, Plymouth, Exeter, Edinburgh, Liverpool, and Brighton.

Report of the Committee appointed by the Council of the British Association for the Advancement of Science to consider the best means for promoting Scientific Education in Schools.

1. A demand for the introduction of Science into the modern system of education has increased so steadily during the last few years, and has re-

ceived the approval of so many men of the highest eminence in every rank and profession, and especially of those who have made the theory and practice of education their study, that it is impossible to doubt the existence of a general, and even a national desire to facilitate the acquisition of some scientific knowledge by boys at our Public and other Schools.

2. We would point out that there is already a *general* recognition of Science as an element in liberal education. It is encouraged, to a greater or less degree, by the English, Scotch, and Irish Universities; it is recognized as an optional study by the College of Preceptors; it forms one of the subjects in the Local Examinations of Oxford and Cambridge; and it has even been partially introduced into several Public Schools. We have added an appendix containing information on some of these points*. But the means at present adopted in our Schools and Universities for making this teaching effective, are, in our opinion, capable of great improvement.

3. That general education in Schools ought to include some training in Science is an opinion that has been strongly urged on the following grounds:—

As providing the best discipline in observation and collection of facts, in the combination of inductive with deductive reasoning, and in accuracy both of thought and language.

Because it is found in practice to remedy some of the defects of the ordinary school education. Many boys on whom the ordinary school studies produce very slight effect, are stimulated and improved by instruction in science; and it is found to be a most valuable element in the education of those who show special aptitude for literary culture.

Because the methods and results of Science have so profoundly affected all the philosophical thought of the age, that an educated man is under a very great disadvantage if he is unacquainted with them.

Because very great intellectual pleasure is derived in after life from even a moderate acquaintance with Science.

On grounds of practical utility as materially affecting the present position and future progress of civilization.

This opinion is fully supported by the popular judgment. All who have much to do with the parents of boys in the upper classes of life are aware that, as a rule, they value education in Science on some or all of the grounds above stated.

4. There are difficulties in the way of introducing Science into schools; and we shall make some remarks on them. They will be found, we believe, to be by no means insuperable.

First among these difficulties is the necessary increase of expense. For if science is to be taught, at least one additional master must be appointed; and it will be necessary in some cases to provide him with additional schoolrooms, and a fund for the purchase of apparatus. It is obvious that the money which will be requisite for both the initial and current expenses, must in general be obtained by increasing the school fees. This difficulty is a real but not a fatal one. In a wealthy country like England, a slight increase in the cost of education will not be allowed (in cases where it is unavoidable) to stand in the way of what is generally looked on as an important educational reform; and parents will not be unwilling to pay a small additional fee if they are satisfied that the instruction in Science is to be made a reality.

Another ground of hesitation is, the fear that the teaching of Science will injure the teaching in classics. But we do not think that there

* See Appendix A.

need be the slightest apprehension that any one of the valuable results of a classical education will be diminished by the introduction of Science. It is a very general opinion, in which schoolmasters heartily concur, that much more knowledge and intellectual vigour might be obtained by most boys, during the many years they spend at school, than what they do as a matter of fact obtain. It should, we think, be frankly acknowledged, and indeed few are found who deny it, that an exclusively classical education, however well it may operate in the case of the very few who distinguish themselves in its curriculum, fails deplorably for the majority of minds. As a general rule the small proportion of boys who leave our schools for the Universities consists undeniably of those who have advanced furthest in classical studies, and judging the existing system of education by these boys alone, we have to confess that it frequently ends in astonishing ignorance. This ignorance, often previously acknowledged and deplored, has been dwelt on with much emphasis, and brought into great prominence by the recent Royal Commission for Inquiry into our Public Schools. We need not fear that we shall do great damage by endeavouring to improve a system which has not been found to yield satisfactory results. And we believe, further, that the philological abilities of the very few who succeed in attaining to a satisfactory knowledge of classics will be rather stimulated than impeded by a more expansive training.

Lastly, it may be objected that an undue strain will be put upon the minds of boys by the introduction of the proposed subjects. We would reply that the same objections were made, and in some schools are still made, to the introduction of Mathematics and Modern Languages, and are found by general experience to have been untenable. A change of studies, involving the play of a new set of faculties, often produces a sense of positive relief; and at a time when it is thought necessary to devote to games so large a proportion of a boy's available time, the danger of a general over-pressure to the intellectual powers is very small, while any such danger in individual cases can always be obviated by special remissions. We do not wish to advocate any addition to the hours of work in schools where it is believed that they are already as numerous as is desirable; but in such schools some hours a week could still be given up to science, by a curtailment of the vastly preponderant time at present devoted to classical studies, and especially to Greek and Latin Composition.

5. To the selection of the subjects that ought to be included in a programme of scientific instruction in public schools we have given our best attention, and we would make the following remarks on the principles by which we have been guided in the selection that we shall propose.

There is an important distinction between scientific *information* and scientific *training*; in other words, between general literary acquaintance with scientific facts, and the knowledge of methods that may be gained by studying the facts at first hand under the guidance of a competent teacher. Both of these are valuable; it is very desirable, for example, that boys should have some general information about the ordinary phenomena of nature, such as the simple facts of Astronomy, of Geology, of Physical Geography, and of elementary Physiology. On the other hand, the scientific habit of mind, which is the principal benefit resulting from scientific training, and which is of incalculable value whatever be the pursuits of after life, can better be attained by a thorough knowledge of the facts and principles of one science, than by a general acquaintance with what has been said or written about many. Both of these should co-exist, we think, at any school which professes to

offer the highest liberal education; and at *every* school it will be easy to provide at least for giving some scientific information.

I. The subjects that we recommend for scientific *information* as distinguished from training, should comprehend a general description of the solar system; of the form and physical geography of the earth, and of such natural phenomena as tides, currents, winds, and the causes that influence climate; of the broad facts of Geology; of elementary Natural History, with especial reference to the useful plants and animals; and of the rudiments of Physiology. This is a kind of information which requires less preparation on the part of the teacher; and its effectiveness will depend on his knowledge, clearness, method, and sympathy with his pupils. Nothing will be gained by circumscribing these subjects by any general syllabus; they may safely be left to the discretion of the masters who teach them.

II. And for scientific *training* we are decidedly of opinion that the subjects which have paramount claims, are Experimental Physics, Elementary Chemistry, and Botany.

i. The science of Experimental Physics deals with subjects which come within the range of every boy's experience. It embraces the phenomena and laws of light, heat, sound, electricity, and magnetism; the elements of mechanics, and the mechanical properties of liquids and gases. The thorough knowledge of these subjects includes the practical mastery of the apparatus employed in their investigation. The study of experimental physics involves the observation and colligation of facts, and the discovery and application of principles. It is both inductive and deductive. It exercises the attention and the memory, but makes both of them subservient to an intellectual discipline higher than either. The teacher can so present his facts as to make them suggest the principles which underlie them, while, once in possession of the principle, the learner may be stimulated to deduce from it results which lie beyond the bounds of his experience. The subsequent verification of his deduction by experiment never fails to excite his interest and awaken his delight. The effects obtained in the class-room will be made the key to the explanation of natural phenomena,—of thunder and lightning, of rain and snow, of dew and hoar-frost, of winds and waves, of atmospheric refraction and reflexion, of the rainbow and the mirage, of meteorites, of terrestrial magnetism, of the pressure and buoyancy of water and of air. Thus the knowledge acquired by the study of experimental physics is, of itself, of the highest value, while the acquisition of that knowledge brings into healthful and vigorous play every faculty of the learner's mind. Not only are natural phenomena made the objects of intelligent observation, but they furnish material for thought to wrestle with and to overcome; the growth of intellectual strength being the sure concomitant of the enjoyment of intellectual victory. We do not entertain a doubt that the competent teacher who loves his subject and can sympathize with his pupils, will find in experimental physics a store of knowledge of the most fascinating kind, and an instrument of mental training of exceeding power.

ii. Chemistry is remarkable for the comprehensive character of the training which it affords. Not only does it exercise the memory and the reasoning powers, but it also teaches the student to gather by his own experiments and observations the facts upon which to reason.

It affords a corrective of each of the two extremes against which real educators of youth are constantly struggling. For on the one hand it leads even sluggish or uncultivated minds from simple and interesting observations to general ideas and conclusions, and gives them a taste of intellectual

enjoyment and a desire for learning. On the other hand, it checks over-confidence in mere reasoning, and shows the way in which valid extensions of our ideas grow out of a series of more and more rational and accurate observations of external nature.

It must not, however, be supposed that all so-called teaching of chemistry produces results of this kind. Young men do occasionally come up to public examinations with a literary acquaintance with special facts and even principles of chemistry, sufficient to enable them to describe those facts from some one point of view, and to enunciate the principles in fluent language, and yet who know nothing of the real meaning of the phrases which they have learnt. Such mere literary acquaintance with scientific facts is in chemistry an incalculable evil to the student if he be allowed to mistake it for science.

Whether the student is to learn much or little of chemistry his very first lessons must be samples of the science. He must see the chief phenomena which are described to him; so that the words of each description may afterwards call up in his mind an image of the thing. He must make simple experiments, and learn to describe accurately what he has done, and what he has observed. He must learn to use the knowledge which he has acquired before proceeding to the acquisition of more; and he must rise gradually from well-examined facts to general laws and theories.

Among the commonest non-metallic elements and their simplest compounds the teacher in a school will find abundant scope for his chief exertions.

iii. Botany has also strong claims to be regarded as a subject for scientific training. It has been introduced into the regular school course at Rugby (where it is the first branch of Natural Science which is studied); and the voluntary pursuit of it is encouraged at Harrow and at some other schools with satisfactory results. It only requires observation, attention, and the acquisition of some new words; but it also evolves the powers of comparison and colligation of facts in a remarkable degree; of all sciences it seems to offer the greatest facilities for observation in the fields and gardens; and to this must be added the fact that boys, from their familiarity with fruits, trees, and flowers, start with a considerable general knowledge of botanical facts. It admits therefore preeminently of being taught in the true scientific method. The teaching of Science is made really valuable by training the learner's mind to examine into his present knowledge, to arrange and criticise it, and to look for additional information. The science must be begun where it touches his past experience, and this experience must be converted into scientific knowledge. The discretion of the teacher will best determine the range of Botany at which it is desirable to aim.

6. The modes of giving instruction in the subjects which we have recommended are reducible to two. I. A compulsory system of instruction may be adopted, similar to that which exists at Rugby, where science has now for nearly three years been introduced on precisely the same footing as Mathematics and Modern Languages, and is necessarily taught to all boys. II. A voluntary system may be encouraged as has been done for many years at Harrow, where scientific instruction on such subjects as have been enumerated above is now given in a systematic series of lectures, on which the attendance of all boys who are interested in them is entirely optional.

Of these systems it is impossible not to feel that the compulsory system is the most complete and satisfactory. The experience of different schools will indicate how it may best be adopted, and what modifications of it may be made to suit the different school arrangements. It will often be very desirable to

supplement it by the voluntary system, to enable the boys of higher scientific ability to study those parts of the course of Experimental Physics which will rarely, if ever, be included in the compulsory school system. Lectures may also be occasionally given by some non-resident lecturer with a view of stimulating the attention and interest of the boys. We add appendices containing details of these two systems as worked at Rugby and Harrow *, and we believe that a combination of the two would leave little or nothing to be desired.

The thorough teaching of the Physical Sciences at schools will not, however, be possible, unless there is a general improvement in the knowledge of Arithmetic. At present many boys of thirteen and fourteen are sent to the Public Schools almost totally ignorant of the elements of Arithmetic, and in such cases they gain only the most limited and meagre knowledge of it; and the great majority enter ill-taught. It is a serious and lasting injury to boys so to neglect Arithmetic in their early education; it arises partly from the desire of the masters of preparatory schools to send up their boys fitted to take a good place in the classical school, and from the indifference of the public schools themselves to the evil that has resulted.

7. With a view to the furtherance of this scheme, we make the following suggestions:—

i. That in all schools Natural Science be one of the subjects to be taught, and that in every Public School at least one Natural Science master be appointed for the purpose.

ii. That at least three hours a week be devoted to such scientific instruction.

iii. That Natural Science should be placed on an equal footing with Mathematics and Modern Languages in affecting promotions, and in winning honours and prizes.

iv. That some knowledge of Arithmetic should be required for admission into all Public Schools.

v. That the Universities and Colleges be invited to assist in the introduction of scientific education, by making Natural Science a subject of examination, either at Matriculation, or at an early period of a University career.

vi. That the importance of appointing Lecturers in Science, and offering Entrance Scholarships, Exhibitions, and Fellowships for the encouragement of scientific attainments be represented to the authorities of the Colleges.

With reference to the last two recommendations, we would observe that, without the cooperation of the Universities, Science can never be effectively introduced into School education. Although not more than 35 per cent., even of the boys at our great Public Schools, proceed to the University, and at the majority of schools a still smaller proportion, yet the curriculum of a public school course is almost exclusively prepared with reference to the requirements of the Universities and the rewards for proficiency that they offer. No more decisive proof could be furnished of the fact that the Universities and Colleges have it in their power to alter and improve the whole higher education of England.

* See Appendices B and C.

APPENDIX A.

I. Oxford.

The Natural Science School at Oxford was established in the year 1853. By recent changes the University allows those who have gained a first, second, or third class in this school to graduate without passing the classical school, provided they have obtained honours, or have passed in three books at least, at the second classical examination, viz., moderations (which is usually passed in the second year of residence); honours in this school are thus placed on an equality with classical honours. The first classical examination, 'responsions,' is generally passed in the first term of residence. Arithmetic and two books of Euclid, or algebra up to simple equations, are a necessary part of this examination.

The University offers ample opportunities for the study of physics, chemistry, physiology, and other branches of natural science. At present only a few of the Colleges have lecturers on this subject; while for classics and mathematics every College professes to have an adequate staff of teachers. At Christ Church, however, a very complete chemical laboratory has been lately opened.

A junior studentship at Christ Church and a demyship at Magdalen College, tenable for five years, are, by the statutes of those Colleges, awarded annually for proficiency in natural science. A scholarship, tenable for three years, lately founded by Miss Brackenbury at Balliol College for the promotion of the study of Natural Science, will be given away every two years. With the exception of Merton College, where a scholarship is to be shortly given for proficiency in natural science, no College has hitherto assigned any scholarships to natural science. The number of scholarships at the Colleges is stated to be about 400, varying in annual value from £100 to £60. With these should be reckoned College exhibitions*, to the number of at least 220, which range in annual value from £145 to £20, and exhibitions awarded at school, many of which are of considerable value.

The two Burdett-Coutts geological scholarships, tenable for two years, and of the annual value of £75, are open to all members of the University who have passed the examination for the B.A degree, and have not exceeded the 27th term from their matriculation. Every year a fellowship of £200 a year, tenable for three years (half of which time must be spent on the Continent) on Dr. Radcliffe's foundation, is at present competed for by candidates who, having taken a first class in the school of natural science, propose to enter the medical profession.

At Christ Church two of the senior studentships (fellowships) are awarded for proficiency in natural science: at the examination for one of these, chemistry is the principal subject, and for the other physiology.

At Magdalen College it is provided that, for twenty years from the year 1857, every fifth fellowship is assigned to mathematics and physical science alternately. In the statutes of this and of every College in Oxford (except Corpus, Exeter, and Lincoln†) the following clause occurs:—"The system of

* At Magdalen College there will be twenty exhibitions tenable for five years, and of the value of £75 a year, to be held by persons in need of support at the University; in the election to these, "the subjects of examination, for one exhibition at least in each year, shall be mathematics and physical science alternately."

† These Colleges exercised the powers of making statutes granted to them by the Oxford University Act of 1854, 17 and 18 Vic. cap. 81. In the statutes of Exeter College it is provided that, in the election of Fellows, "preference shall be given to those candidates in whom shall be found the highest moral and intellectual qualifications, such intellectual qualifications having been tested by an examination in such subjects as the College from time

examinations shall always be such as shall render fellowships accessible, from time to time, to excellence in every branch of knowledge for the time being recognized in the schools of the University." This clause, so far as it relates to the study of natural science, has been acted on only by Queen's College and at Merton College, where a natural-science fellowship will be filled up during the course of the present year.

At Pembroke College one of the two Sheppard fellows must proceed to the degree of Bachelor and Doctor of Medicine in the University. At the late election to this fellowship natural science was the principal subject in the examination. The number of College fellowships in Oxford is at present about 400.

II. Cambridge.

It is important to distinguish between the University and the Colleges at Cambridge as at Oxford.

There is a natural-science tripos in which the University examines in the whole range of natural sciences, and grants honours precisely in the same manner as in classics or mathematics.

The University also recognizes the natural sciences as an alternative subject for the ordinary degree. As the regulations on this point are comparatively recent, it will be well to state them here.

A student who intends to take an ordinary degree without taking honours has to pass three examinations during his course of three years,—the first, or previous examination, after a year's residence, in Paley, Latin, Greek, Euclid, and arithmetic, and one of the Gospels in Greek; the second, or general examination, towards the end of his second year, in the Acts of the Apostles in Greek, Latin, Greek, Latin prose composition, algebra, and elementary mechanics; and the third, or special examination, at the end of his third year, in one of the following five subjects:—1. Theology; 2. Moral Science; 3. Law; 4. Natural Science; 5. Mechanism and applied science.

In the natural-science examination a choice is given of chemistry, geology, botany, and zoology.

There are only five Colleges in Cambridge that take any notice of Natural Science; namely, King's, Caius, Sidney Sussex, St. John's, and Downing. At King's two exhibitions have been given away partly for proficiency in this subject; but there are no lectures, and it is doubtful whether similar exhibitions will be given in future. At Caius there is a medical lecturer and one scholarship given away annually for Anatomy and Physiology. At Sidney Sussex two scholarships annually are given away for mathematics and natural science; and a prize of £20 for scientific knowledge. There is also a laboratory for the use of students. At St. John's there is a chemical lecturer and laboratory; and though at this College there is no sort of examination in natural science either for scholarships or fellowships, it is believed distinction in the subject may be taken into account in both elections. Downing was founded with "especial reference to the studies of Law and Medicine;" there is a lecturer here in medicine and natural science, and in the scholarship examinations one paper in these subjects; no scholarship is appropriated to them, but they are allowed equal weight with other subjects

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to time shall determine." In the statutes of Lincoln College the following clause occurs:—"Pateat autem societas non iis tantum, qui in literis Græcis et Latinis se profecisse probaverint, sed etiam aliarum bonarum artium peritis juvenibus." And in the statutes of Corpus Christi College, "Quicunque se candidatos offerant examinentur in bonis literis et scientiis, sicut Præsidenti et sociis videbitur."

in the choice of candidates. It is believed that the same principle will govern the election to fellowships in this College, though no fellowship has yet been given for honours in natural science. We believe that, owing to the new University regulations (mentioned above), the authorities of Trinity College have determined to appoint a lecturer in natural science; the matter is under deliberation in other Colleges, and it is not improbable that the same considerations will induce them to follow this example.

It must always be remembered that the practice is rare in Cambridge of appropriating fellowships and scholarships to special subjects. At present public opinion in the University does not reckon scientific distinction as on a par with mathematical or classical; hence the progress of the subject seems enclosed in this inevitable circle—the ablest men do not study natural science because no rewards are given for it, and no rewards are given for it because the ablest men do not study it. But it may be hoped that the disinterested zeal of teachers and learners will rapidly break through this circle; in that case the subject may be placed on a satisfactory footing without any express legislative provision.

III. The University of London.

At the University of London the claims of science to form a part of every liberal education have long been recognized. At the Matriculation Examination the student is required to show that he possesses at least a popular knowledge of the following subjects:—

a. In *Mechanics*: the composition and resolution of forces; the mechanical powers; a definition of the centre of gravity; and the general laws of motion.

b. In *Hydrostatics, Hydraulics,* and *Pneumatics*: the pressure of liquids and gases; specific gravity; and the principles of the action of the barometer, the siphon, the common pump and forcing-pump, and the air-pump.

c. In *Acoustics*: the nature of sound.

d. In *Optics*: the laws of refraction and reflection, and the formation of images by simple lenses.

e. In *Chemistry*: the phenomena and laws of heat; the chemistry of the non-metallic elements; general nature of acids, bases, &c.; constitution of the atmosphere; composition of water, &c.

At the examination for the degree of B.A. a more extensive knowledge of these subjects is required, and the candidate is further examined in the following branches of science:—

f. *Astronomy*: principal phenomena depending on the motion of the earth round the sun, and on its rotation about its own axis; general description of the solar system, and explanation of lunar and solar eclipses.

g. *Animal Physiology*: the properties of the elementary animal textures; the principles of animal mechanics; the processes of digestion, absorption, assimilation; the general plan of circulation in the great divisions of the animal kingdom; the mechanism of respiration; the structure and actions of the nervous system; and the organs of sense.

Besides the degree examination there is also an examination for *honours* in mathematics and natural philosophy, in which, of course, a much wider range of scientific knowledge is required.

We would venture to remark that, if a similar elementary acquaintance with the general principles of sciences were required for matriculation at

Oxford and Cambridge, it is certain that they would at once become a subject of regular teaching in all our great public schools.

There are also two specially scientific degrees, a Bachelor of Science and a Doctor of Science. For the B.Sc. there are two examinations of a general but highly scientific character. The degree of D.Sc. can only be obtained after the expiration of two years subsequent to taking the degree of B.Sc. The candidate is allowed to select one *principal subject*, and to prove his thorough practical knowledge thereof, as well as a general acquaintance with other subsidiary subjects.

IV. The College of Preceptors.

In the diploma examinations at the College of Preceptors, one branch of science, viz. either chemistry, natural history, or physiology, is required as a *necessary* subject for the diploma of *Fellow*. In the examinations for the lower diploma of Associate or Licenciate some branch of science *may* be taken up by candidates at their own option. The Council recently decided to offer a prize of three guineas half-yearly for the candidate who showed most proficiency in science, and who at the same time obtained a second class in the other subjects.

In the examinations of pupils of schools, natural philosophy, chemistry, and natural history are optional subjects only, and are not *required* for a certificate for the three classes. Two prizes are given to those candidates who obtain the highest number of marks in these subjects at the half-yearly examinations; and it is an interesting fact that last year, out of a total of 651 candidates, 100 brought up natural history, and 36 brought up chemistry as subjects for examination. Two additional prizes were consequently awarded.

V. The French Schools.

In France the "Lycées" correspond most nearly to our Public Schools, and for many years science has formed a distinct part of their regular curriculum. A strong impulse to the introduction of scientific teaching into French schools was given by Napoleon I., and since that time we believe that no French school has wholly neglected this branch of education. The amount of time given to these subjects appears to average two hours in every week.

The primary education is that which is given to all alike, whatever may be their future destination in life, up to the age of eleven or twelve years. After this period there is a "bifurcation" in the studies of boys. Those who are intended for business or for practical professions lay aside Greek and Latin, and enter on a course of "special secondary instruction." In this course mechanics, cosmography, physics, chemistry, zoology, botany, and geology occupy a large space; and the authorized official programmes of these studies are very full, and are drawn up with the greatest care. The remarks and arguments of the Minister of Public Instruction (Mons. Duruy) and others, in the "Programmes officiels &c. de l'enseignement secondaire spécial," are extremely valuable and suggestive; and we recommend the syllabuses of the various subjects, which have received the sanction of the French Government, as likely to afford material assistance to English teachers in determining the range and limits of those scientific studies at which, in any special system of instruction, they may practically aim. The "Enseignement secondaire spécial" might very safely be taken as a model of what it is desirable to teach in the "modern departments" which are now attached to some of our great schools.

The boys who are destined to enter the learned professions continue a classical course, in which, however, much less time is devoted to classical composition than is the case in our Public Schools. Nor is science by any means neglected in this course, which is intended to cover a period of three years. Besides the "elementary division" there are five great classes in these schools, viz., a grammar division, an upper division, a philosophy class, and classes for elementary and special mathematics.

In the grammar division there is systematic instruction on the physical geography of the globe.

In the second class of the upper division the boys begin to be taught the elements of zoology, botany, and geology in accordance with the ministerial programmes; and in the rhetoric class descriptive cosmography (which seems to be nearly coextensive with the German *Erdkunde*) forms the subject of a certain number of weekly lessons.

In the class of philosophy, the young students are initiated into the elementary notions of physics (including weight, heat, electricity and magnetism, acoustics, and optics) and of chemistry, in which, at this stage, the teaching is confined to "general conceptions on air, water, oxidation, combustion, the conditions and effects of chemical action, and on the forces which result from it."

In the classes of elementary and special mathematics this course of scientific training is very considerably extended; and if the authorized programmes constitute any real measure of the teaching, it is clear that no boy could pass through these classes without a far more considerable amount of knowledge in the most important branches of science than is at present attainable in any English Public School.

VI. The German Schools.

In Germany the schools which are analogous to Public Schools in England are the *Gymnasia*, where boys are prepared for the Universities, and the *Bürgerschulen* or *Realschulen*, which were established for the most part about thirty years ago for the purpose of affording a complete education to those who go into active life as soon as they leave school. An account of the Prussian Gymnasia and Realschulen may be seen in the Public-School Commission Report, Appendix G; further information may be obtained in 'Das höhere Schulwesen in Preussen,' by Dr. Wiese, published under the sanction of the Minister of Public Instruction in Prussia, and in the programmes issued annually by the school authorities throughout Germany*.

At the Gymnasia natural science is not taught to any great extent. According to the Prussian official instructions, in the highest class two hours, and in the next class one hour, a week are allotted to the study of physics. In the lower classes two hours a week are devoted to natural history, *i. e.* botany and zoology. The results of the present training in natural science at the Gymnasia are considered by many eminent University professors in Germany to be unsatisfactory, owing to the insufficient time allotted to it.

In the Realschulen about six hours a week are given to physics and chemistry in the two highest classes, and two or three hours a week to natural history in the other classes. In these schools all the classes devote five or six hours a week to mathematics, and no Greek is learnt. In Prussia there were in 1864 above 100 of these schools.

* See also Étude sur l'instruction secondaire et supérieure en Allemagne, par J. F. Minssen, Paris, 1866. A brief Report addressed to the Minister of Public Instruction in France.

APPENDIX B.

On the Natural-Science Teaching at Rugby.

Before the summer of 1864 a boy on entering Rugby might signify his wish to learn either modern languages or natural science; the lessons were given at the same time, and therefore excluded one another. If he chose natural science he paid an entrance fee of £1 1*s*., which went to an apparatus fund, and £5 5*s*. annually to the lecturer. Out of the whole school, numbering from 450 to 500, about one-tenth generally were in the natural science classes.

The changes proposed by the Commissioners were as follows:—That natural science should no longer be an alternative with modern languages, but that all boys should learn some branch of it. That there should be two principal branches,—one consisting of chemistry and physics, the other of physiology and natural history, animal and vegetable; and that the classes in natural science should be entirely independent of the general divisions of the school, so that boys might be arranged for this study exclusively according to their proficiency in it.

Since, owing to circumstances which it would be tedious to detail, it was impossible to adopt literally the proposals of the Commissioners, a system was devised, which must be considered as the system of the Commissioners in spirit, adapted to meet the exigencies of the case.

The general arrangement is this,—that new boys shall learn botany their first year, mechanics their second, geology their third, and chemistry their fourth.

In carrying out this general plan certain difficulties occur, which are met by special arrangements depending on the peculiarities of the school system. We need not here enter upon these details, because it would be impossible to explain them simply, and because any complications which occur in one school would differ widely from those which are likely to arise in another.

Next, as to the nature of the teaching.

In botany the instruction is given partly by lectures and partly from Oliver's Botany. Flowers are dissected and examined by every boy, and their parts recognized and compared in different plants, and then named. No technical terms are given till a familiarity with the organ to be named or described has given rise to their want. The terms which express the cohesion and adhesion of the parts are gradually acquired until the floral schedule, so highly recommended by Henslow and Oliver, can be readily worked. Fruit, seed, inflorescence, the forms of leaf, stem, root are then treated, the principal facts of vegetable physiology illustrated, and the principle of classification into natural orders explained, for the arrangement of which Bentham's 'Handbook of the British Flora' is used. Contrary to all previous expectation, when this subject was first introduced it became at once both popular and effective among the boys.

The lectures are illustrated by Henslow's nine diagrams, and by a large and excellent collection of paintings and diagrams made by the lecturers and their friends, and by botanical collections made for use in lectures. When the year's course is over, such boys as show a special taste are invited to take botanical walks with the principal lecturer, to refer to the School Herbarium, and are stimulated by prizes for advanced knowledge and for dried collections, both local and general.

In mechanics the lecturer is the senior Natural Science Master. The lectures include experimental investigations into the mechanical powers, with

numerous examples worked by the boys; into the elements of mechanism, conversion of motion, the steam-engine, the equilibrium of roofs, bridges, strength of material, &c. They are illustrated by a large collection of models, and are very effective and popular lectures.

The lectures in geology are undertaken by another master. This subject is only temporarily introduced, on account of the want of another experimental school. When this is built the third year's course will be some part of experimental physics, for which there already exists at Rugby a fair amount of apparatus. It is very desirable that boys should obtain some knowledge of geology, but it is not so well fitted for school teaching as some of the other subjects on several grounds. Perhaps a larger proportion of boys are interested in the subject than in any other; but the subject presupposes more knowledge and experience than most boys possess, and their work has a tendency to become either superficial, or undigested knowledge derived from books alone. The lectures include the easier part of Lyell's Principles, *i. e.* the causes of change now in operation on the earth; next, an account of the phenomena observable in the crust of the earth, stratification and its disturbances, and the construction of maps and sections; and, lastly, the history of the stratified rocks and of life on the earth. These lectures are illustrated by a fair geological collection, which has been much increased of late, and by a good collection of diagrams and views to illustrate geological phenomena.

For chemistry the lecturer has a convenient lecture-room and a small but well-fitted laboratory*, and he takes his classes through the non-metallic and the metallic elements: the lectures are fully illustrated by experiments. Boys, whose parents wish them to study chemistry more completely, can go through a complete course of practical analysis in the laboratory, by becoming private pupils of the teacher. At present twenty-one boys are studying analysis.

This being the matter of the teaching, it remains to say a few words on the manner. This is nearly the same in all the classes, *mutatis mutandis*: the lecture is given, interspersed with questions, illustrations, and experiments, and the boys take rough notes, which are recast into an intelligible and presentable form in note-books. These are sent up about once a fortnight, looked over, corrected, and returned; and they form at once the test of how far the matter has been understood, the test of the industry, care, and attention of the boy, and an excellent subject for their English composition.

Examination papers are given to the sets every three or four weeks, and to these and to the note-books marks are assigned which have weight in the promotion from form to form. The marks assigned to each subject are proportional to the number of hours spent in school on that subject.

There are school prizes given annually for proficiency in each of the branches of natural science above mentioned.

This leads us, lastly, to speak of the results.

First, as to the value of the teaching itself; secondly, as to its effects on the other branches of study.

The experience gained at Rugby seems to point to these conclusions:—That botany, structural and classificatory, may be taught with great effect and interest a large number of boys, and is the best subject to start with. That its exactness of terminology, the necessity of care in examining the flowers, and the impossibility of superficial knowledge are its first recommendations; and the successive gradations in the generalizations as to the unity of type of flowers, and the principles of a natural classification, are of great value to

* Another and larger laboratory and school for Experimental Physics will shortly be built at Rugby.

the cleverer boys. The teaching must be based on personal examination of flowers, assisted by diagrams, and everything like cram strongly discouraged.

Mechanics are found rarely to be done well by those who are not also the best mathematicians. But it is a subject which in its applications interest many boys, and would be much better done, and would be correspondingly more profitable, if the standard of geometry and arithmetic were higher than it is. The ignorance of arithmetic which is exhibited by most of the new boys of fourteen or fifteen would be very surprising, if it had not long since ceased to surprise the only persons who are acquainted with it; and it forms the main hindrance to teaching mechanics. Still, under the circumstances, the results are fairly satisfactory.

The geological teaching need not be discussed at length, as it is temporary, at least in the middle school. Its value is more literary than scientific. The boys can bring neither mineralogical, nor chemical, nor anatomical knowledge; nor have they observed enough of rocks to make geological teaching sound. The most that they can acquire, and this the majority do acquire, is the general outline of the history of the earth and of the agencies by which that history has been effected, with a conviction that the subject is an extremely interesting one. It supplies them with an object rather than with a method.

Of the value of elementary teaching in chemistry there can be only one opinion. It is felt to be a new era in a boy's mental progress when he has realized the laws that regulate chemical combination and sees traces of order amid the seeming endless variety. But the number of boys who get real hold of chemistry *from lectures alone* is small, as might be expected from the nature of the subject.

Of the value of experimental teaching in physics, especially pneumatics, heat, acoustics, optics, and electricity, there can be no doubt. Nothing but impossibilities would prevent the immediate introduction of each of these subjects in turn into the Rugby curriculum.

Lastly, what are the general results of the introduction of scientific teaching in the opinion of the body of masters? In brief it is this, that the school as a whole is the better for it, and that the scholarship is not worse. The number of boys whose industry and attention is not caught by any school study is decidedly less; there is more respect for work and for abilities in the different fields now open to a boy; and though pursued often with great vigour, and sometimes with great success, by boys distinguished in classics, it is not found to interfere with their proficiency in classics, nor are there any symptoms of overwork in the school. This is the testimony of classical masters, by no means specially favourable to science, who are in a position which enables them to judge. To many who would have left Rugby with but little knowledge, and little love of knowledge, to show as the results of their two or three years in our middle school, the introduction of science into our course has been the greatest possible gain: and others who have left from the upper part of the school, without hope of distinguishing themselves in classics or mathematics, have adopted science as their study at the Universities. It is believed that no master in Rugby School would wish to give up natural science and recur to the old curriculum.

APPENDIX C.

On the Teaching of Science at Harrow School.

From this time forward natural science will be made a regular subject for systematic teaching at Harrow, and a natural science master has been appointed.

But for many years before the Royal Commission for Inquiry into the Public Schools had been appointed, a voluntary system for the encouragement of science had been in existence at Harrow. There had been every term a voluntary examination on some scientific subject, which, together with the text-books recommended, was announced at the end of the previous term. Boys from all parts of the school offered themselves as candidates for these voluntary examinations, and every boy who acquitted himself to the satisfaction of the examiners (who were always two of the masters) was rewarded with reference to what could be expected from his age and previous attainments. The text-books were selected with great care, and every boy really interested in his subject could and did seek the private assistance of his tutor or of some other master. The deficiencies of the plan, if regarded as a *substitute* for the more formal teaching of science, were too obvious to need pointing out; yet its results were so far satisfactory that many old Harrovians spoke of it with gratitude, among whom are some who have since devoted themselves to science with distinguished success.

One of the *main* defects of this plan (its want of all system) was remedied a year ago, when two of the masters drew up a scheme, which was most readily adopted, by which any boy staying at Harrow for three years might at least have the opportunity during that time of being introduced to the elementary conceptions of astronomy, zoology, botany, structural and classificatory, chemistry, and physics. These subjects were entrusted to the responsibility of eight of the masters, who drew up with great care a syllabus on the subject for each term, recommend the best text-books, and give weekly instruction (which is perfectly gratuitous) to all the boys who desire to avail themselves of it; indeed a boy may receive, in proportion to the interest which he manifests in the subject, almost any amount of assistance which he may care to seek. Proficiency in these examinations is rewarded as before; and to encourage steady perseverance, the boys who do best in the examination during a course of *three* terms receive more valuable special rewards.

As offering to boys a voluntary and informal method of obtaining much scientific information this plan (which was *originated* at Harrow, and has not, so far as we are aware, been ever adopted at any other school) offers many advantages. It is sufficiently elastic to admit of many modifications; it is sufficiently comprehensive to attract a great diversity of tastes and inclinations; it cannot be found oppressive, because it rests with each boy to decide whether he has the requisite leisure or not; it can be adopted with ease at any school where even a small body of the masters are interested in one or other special branch of science; and it may tend to excite in some minds a more spontaneous enthusiasm than could be created by a compulsory plan alone.

We would not, however, for a moment recommend the adoption of any such plan as a *substitute* for more regular scientific training. Its chief value is purely *supplemental,* and henceforth it will be regarded at Harrow as entirely subordinate to the formal classes for the teaching of science which will be immediately established.

In addition to this, more than a year ago some of the boys formed them-

selves into a voluntary association for the pursuit of science. This Scientific Society, which numbers upwards of thirty members, meets every ten days at the house and under the presidency of one or other of the masters. Objects of scientific interest are exhibited by the members, and papers are read generally on some subject connected with natural history. Under the auspices of this Society the nucleus of a future museum has already been formed; and among other advantages the Society has had the honour of numbering among its visitors more than one eminent representative of literature and science. We cannot too highly recommend the encouragement of such associations for intellectual self-culture among the boys of our public schools.

Report of the Kew Committee of the British Association for the Advancement of Science for 1866–67.

The Committee of the Kew Observatory submit to the Council of the British Association the following statement of their proceedings during the past year:—

At the Nottingham Meeting it was resolved, "That the Kew Committee be authorized to discuss and make the necessary arrangements with the Board of Trade, should any proposal be made respecting the superintendence, reduction, and publication of Meteorological observations, in accordance with the recommendations of the Report of the Committee appointed to consider certain questions relating to the Meteorological Department of the Board of Trade."

On the 18th of October last, a joint Meeting of the Kew Committee, and of the President, Vice-Presidents, and other Officers of the Royal Society, took place, to take into consideration a communication which had been received by the President of the Royal Society from the Board of Trade relative to the Meteorological Department, and to consider what reply should be sent.

At this joint Meeting it was recommended that the Department under whose care the Meteorological observations, reductions, and tabulations are to be made should be under the direction and control of a Superintending Scientific Committee, who should (subject to the approval of the Board of Trade) have the nomination to all appointments, as well as the power of dismissing the usual officials receiving salaries or remuneration. It was also understood that while the services of the Committee were to be gratuitous, they would yet necessarily require the services and assistance of a competent paid Secretary.

Finally, the draft of a reply to the above-mentioned communication from the Board of Trade was agreed to at this Meeting, for consideration of the Council of the Royal Society.

The Council of the Royal Society, on 13th Dec. 1866, nominated the following Fellows of the Society as the Superintending Meteorological Committee:—General Sabine, Pres. R.S., Mr. De la Rue, Mr. Francis Galton, Mr. Gassiot, Dr. W. A. Miller, Captain Richards (Hydrographer of the Admiralty), Colonel Smythe, and Mr. Spottiswoode; and on the 3rd of January this Committee appointed Mr. Balfour Stewart as its Secretary, on the understanding that he should, with the concurrence of the Kew Committee of the British Association, retain his present office of Superintendent of the Kew Observatory.

It was also proposed that Kew Observatory should become the Central Observatory, at which all instruments used by or prepared for the several observatories or stations connected with the Meteorological Department should

be verified,—the entire expense attendant thereon, or any future expense arising through the connexion of the Observatory with the Meteorological Department being paid from the funds supplied by the latter, and not in any way from money subscribed by the British Association. These proposals having been submitted to the Kew Committee, they approved of the Kew Observatory being regarded as the Central Observatory of the Meteorological Department, and of Mr. Stewart's holding the office of Secretary to the Scientific Committee superintending that Department.

When the Meteorological Department was placed under the superintendence of a Scientific Committee, one of the main objects contemplated was the establishment of a series of meteorological observatories, working in unison with the Kew Observatory, provided with similar self-recording instruments, and distributed throughout the country in such a manner that by their means the progress of meteorological phenomena over the British Isles might be recorded with great exactness.

For this purpose it was proposed to have observatories in the following places:—

Kew (Central Observatory).	Aberdeen (probably).
Falmouth.	Armagh.
Stonyhurst.	Valencia.
Glasgow.	

Such a plan of course involves an additional annual expenditure; but, the appointment of a Committee having been sanctioned in the first instance by the Government, and the estimates attendant thereon afterwards by the House of Commons, the arrangement may now be regarded as established, without involving any additional expense to the British Association. The consequence will be a considerable access of work to Kew Observatory, and the duties now undertaken by that establishment may, for clearness' sake, be considered under the two following heads:—

(A) The work done by Kew Observatory under the Direction of the British Association.

(B) That done at Kew as the Central Observatory of the Meteorological Committee.

This system of division will be adopted in what follows of this Report.

(A) Work done by Kew Observatory under the Direction of the British Association.

1. *Magnetic.*—The Self-recording Magnetographs ordered by the Victoria Government for Mr. Ellery, of Melbourne, have been verified at Kew, and dispatched to Melbourne, where they have arrived. They will, it is believed, be very shortly in continuous action.

It was mentioned in the last Report that a set of Self-recording Magnetographs ordered by the Stonyhurst Observatory had been verified at Kew and dispatched to their destination. These instruments are now in action at Stonyhurst, under the direction of the Rev. W. Sidgreaves.

Mr. Meldrum, of the Mauritius Observatory, who is now in this country, has received at Kew instruction in the various processes of that establishment. His Self-recording Magnetographs have been verified in his presence, and they are now in the hands of the optician, who is awaiting Mr. Meldrum's instructions regarding them.

It is hoped that very soon a considerable number of Magnetographs after the Kew pattern will be in continuous operation at different parts of the

world; and as during the next two or three years magnetic disturbances may be expected to increase, it will be interesting to institute comparisons between the simultaneous records produced by these various instruments.

The usual monthly absolute determinations of the magnetic elements continue to be made by Mr. Whipple, magnetic assistant; and the Self-recording Magnetographs are in constant operation as heretofore, also under Mr. Whipple, who has displayed much care and assiduity in the discharge of his duties.

The photographic department connected with the self-recording instruments is under the charge of Mr. Page, who performs his duties very satisfactorily.

The observations made for the purpose of determining the temperature coefficients of the horizontal-force and vertical-force magnetographs have been reduced.

In order to obviate the chance of any break in the continuity of the series of absolute magnetic determinations made at Kew which might arise from a change of the magnetic assistant, the Superintendent has commenced taking quarterly observations of the dip and horizontal force, with the view of correcting any change in *personal equation* which might be produced by change of assistant.

The magnetic curves produced at Kew previously to the month of January 1865, have all been measured and reduced under the direction of General Sabine, by the staff of his office at Woolwich, and the results of this reduction have been communicated by General Sabine to the Royal Society in a series of interesting and valuable memoirs. It is now proposed that the task of tabulating and reducing these curves since the above date be performed by the staff at Kew working under the direction of Mr. Stewart.

2. *Meteorological work.*—The meteorological work of the Observatory continues in charge of Mr. Baker, who executes his duties very satisfactorily.

Since the Nottingham Meeting 89 Barometers have been verified; 608 Thermometers have likewise been verified, and two Standard Thermometers have been constructed at the Observatory.

The Self-recording Barograph continues in constant operation, and traces in duplicate are obtained, one set of which is regularly forwarded to the Meteorological Office.

A Self-recording Barograph and Thermograph on the new Kew pattern about to be made for Mr. Ellery of Melbourne, and a Self-recording Barograph for Mr. Smalley of Sydney, will be verified at the observatory before they are dispatched to their destination.

The Anemometer is in constant operation as heretofore.

Dr. R. Coleridge Powles, before he proceeded to Pekin, received meteorological instruction at Kew.

The well-known apparatus employed for so long a time by Mr. Robert Addams for liquefying carbonic acid, has been purchased by Mr. Stewart from funds supplied by the Royal Society; and Mr. Addams has kindly undertaken to make a preliminary experiment with his apparatus, as well as to give specific instructions regarding it. As the exact thermometric value of the freezing-point of mercury has been previously determined by Mr. Stewart, it is expected that the apparatus will furnish the means of verifying thermometers at very low temperatures.

At the request of the Meteorological Committee, several Aneroids have been obtained from the best-known makers of these instruments, and, by means of an apparatus constructed by Mr. Beckley for this purpose, they have been compared with a standard Barometer at different pressures, being

meanwhile tapped so as to imitate as well as possible the tapping by the hand which these instruments are usually subjected to previously to the readings being taken.

These experiments show that, while Aneroids cannot be considered equal in accuracy to standard Barometers, yet the best-constructed Aneroids, within certain limits, give reliable results.

3. *Photoheliograph.*—The Kew Heliograph, in charge of Mr. De la Rue, continues to be worked in a satisfactory manner. During the past year 204 negatives have been taken, on 144 days. Pictures of the Pagoda in Kew Gardens are regularly taken by this instrument, in the hope that by this means the angular diameter of the Sun may be satisfactorily determined. Since the last Meeting of the Association, a second series of solar researches, in continuation of the first series, has been published (the expense of printing having been defrayed by Mr. De la Rue), entitled "Researches in Solar Physics, Second Series, Area Measurements of the Sun-spots observed by Mr. Carrington during the seven years 1854–1860 inclusive, and deductions therefrom. By Messrs. De la Rue, Stewart, and Loewy."

The Heliographic latitudes and longitudes of all the spots recorded by the Kew Photoheliograph during the years 1862 and 1863 have been calculated, and it is hoped that the results may soon be published, forming a third series of Solar Researches. It is believed that these results will demonstrate the superiority of photographic pictures over all other methods of observation.

The sum of £60 has been obtained from the Government Grant fund of the Royal Society, to be applied to the discussion of Hofrath Schwabe's long and valuable series of Sun-spots, at present in the possession of Kew Observatory. These pictures are now being examined with this object.

Sun-spots continued likewise to be numbered after the manner of Hofrath Schwabe, and a table exhibiting the monthly groups observed at Dessau and at Kew for the year 1866 has already appeared in the Monthly Notices of the Astronomical Society, vol. xxvii. No. 3.

4. *Apparatus for verifying Sextants.*—The apparatus constructed by Mr. Cooke, for verifying Sextants, has for some time been erected at the Observatory; and a description of it has been communicated by Mr. Stewart to the Royal Society, and published in their 'Proceedings,' vol. xvi. p. 2.

Seven Sextants have been verified during the past year.

5. *Miscellaneous work.*—The preliminary observations with Captain Kater's pendulum, alluded to in last year's Report, have been made; but the reductions are not yet quite finished.

An account of certain experiments on the heating of a disk by rapid rotation *in vacuo* has been communicated to the Royal Society by Mr. Stewart in conjunction with Professor Tait, and has been published in the 'Proceedings' of that body.

The instrument devised by Mr. Broun for the purpose of estimating the magnetic dip by means of soft iron, remains at present at the Observatory, awaiting Mr. Broun's return to England.

During the past year two standard yards for opticians have been compared with the Kew standard.

Several instruments, chiefly magnetic, have been sent to Kew by General Sabine from his office at Woolwich.

The Superintendent has received grants from the Royal Society for special experiments; and when these are completed an account will be rendered to that Society.

(B) Work done at Kew as the Central Observatory of the Meteorological Committee.

Mr. Stewart, as Director of the Central Meteorological Observatory, having been called upon to arrange the self-recording instruments required by the Meteorological Committee, has obtained the cooperation of Mr. Beckley, mechanical assistant at Kew, from whom he has derived very great aid, and in conjunction with him has arranged the Self-recording Thermograph and Barograph which have been adopted by the Meteorological Committee.

The following are the chief characteristics of these instruments:—

Thermograph.—In this instrument an air-speck, formed by a break in the mercurial column of a thermometer, allows the light of a gas-lamp to pass through it, yielding an image that is obtained on a revolving cylinder covered with photographic paper.

As the cylinder revolves once in forty-eight hours, and as the thermometric column rises and falls, these motions delineate a curve, by means of which the temperature of the thermometer is denoted from moment to moment. There would be but one curve if there were only one thermometer; in practice there are two, the dry and wet bulb, the object of the first being to register the temperature of the air, and of the second to register that of evaporation. In this Thermograph the simultaneous records of these two thermometers are obtained, the one under the other, on the same sheet of paper. We have thus an under curve denoting the readings of the wet-bulb thermometer, and a curve above it denoting those of the dry-bulb thermometer.

An arrangement connected with the clock of this instrument has been proposed and executed by Mr. Beckley, by means of which the light is cut off from the sensitive paper for four minutes every two hours. A small break is thus produced every two hours on each curve, by means of which the time of any phenomenon may be easily ascertained. By drawing lines through the simultaneous breaks of the wet and dry-bulb curves, a series of lines is obtained perpendicular to the direction of motion of the cylinder, which serves the purposes of a zero-line. Lastly, a Kew Standard Thermometer, similar in size and figure to those of the Thermograph, and placed between them (outside the house), is used as the standard of reference, and, as such, is read (by eye) five or six times a day. By this means an independent determination of the temperature of the air may be obtained from time to time.

The Thermograph has been for some time ready to commence continuous registration. Hitherto this has been delayed with the view of making experiments designed to improve the working of the instrument, because up to the present time these improvements could be easily adapted to the other instruments in course of construction. It is intended to commence the regular working of the instrument before the beginning of September.

Barograph.—The arrangement for cutting off the light every two hours, and the precaution of comparing the observations with those of a standard instrument, read five or six times a day, will be introduced in the Barograph as well as in the Thermograph. The correction of the Barograph for temperature is the only thing to which it is necessary to allude. Here the curve denotes an uncorrected Barometer: the zero-line is not a straight line, but is formed by the interception of the light from the cylinder by a stop which, by means of a lever arrangement, rises and falls with temperature as much as the barometric column rises and falls from the same cause; that is to

Accounts of the Kew Committee of the British Association from August 22, 1866, to September 4, 1867.

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance from last account				22	9	9
Received from the General Treasurer				600	0	0
" for the verification of Meteorological Instruments from the Meteorological Office	22	19	0			
" " from Opticians	31	9	2			
" for Barograph Curves sent to the Meteorological Office, London	26	0	0			
" for the verification of self-recording Magnetographs	60	0	0			
" from Prof. Roscoe for time employed in making actinic observations	24	0	0			
				164	8	2
				£786	17	11

PAYMENTS.

	£	s.	d.	£	s.	d.
Salaries, &c.:—						
To B. Stewart, four quarters, ending 1st October, 1867	200	0	0			
Ditto, allowed for petty travelling expenses	10	0	0			
G. Whipple, four quarters, ending 18th September, 1867	100	0	0			
T. Baker, four quarters, ending 29th September, 1867	75	0	0			
F. Page, two quarters at £40 per annum	20	0	0			
Ditto, two quarters, ending 2nd October, 1867, at £50 per annum	25	0	0			
R. Beckley, 54 weeks, ending 2nd September 1867, at 40*s.* per week	108	0	0			
				538	0	0
Apparatus, Materials, Tools, &c.				51	14	8
Ironmonger, Carpenter, and Mason				13	18	3
Printing, Stationery, Books, and Postage				56	19	2
Coals and Gas				49	7	0
House Expenses, Chandlery, &c.				27	16	8
Porterage and petty expenses				26	14	10
Rent of Land to 10th October, 1867				11	0	0
Brushwood for ditch				1	5	0
Balance				10	2	4
				£786	17	11

I have examined the above account and compared it with the vouchers presented to me.

	£	s.	d.
The Balance from the last year	£ 22	9	9
Received from the Treasurer of the British Association	600	0	0
From Sundries, for the construction and verification of instruments	164	8	2
	786	17	11
The total Expenditure for the year	776	15	7
Leaving a balance in hand amounting to	£ 10	2	4

15th August, 1867.

R. HUTTON.

say, in order to find the true height of the barometer, we measure between the zero-line and the line denoting the top of the uncorrected column, since, when the top of the column rises or falls through temperature, the zero-line rises or falls just as much. This mode of correction, although sufficient for most purposes, cannot yet be absolutely perfect; a little reflection will, however, show that the curved zero-line may not only be used as the means of correcting the readings of the instrument, but also as giving the actual temperature of the mercurial column from moment to moment, so that the true temperature-correction may with very little trouble be obtained and applied.

A comparison of the curves of the old Kew Barograph at present in operation, with those of the Oxford Barograph, has shown that there is probably a slight adhesion of the mercury to the sides of the tube of the former instrument; moreover the instrument is not in all respects the same as those about to be supplied to the other observatories. It has therefore been resolved that one of the new instruments shall be substituted for it.

Anemometer.—This instrument is a modification of Dr. Robinson's. Its time-scale corresponds in length with those of the Thermograph and Barograph,—the object of having all the time-scales of the same length being to obtain the means of accurately placing the simultaneous records of the different instruments, one under the other, on the same sheet of paper. The present Anemometer will have to be altered, as it is not self-recording for direction; and it is then intended to support it above the moveable dome of the Observatory so as to be independent of it.

In order to fit the Observatory for the purposes of the Meteorological Committee, one of the outhouses, at present only occasionally used for the verification of Magnetographs, has been altered so as to make it also available for the verification of meteorological self-recording instruments; this, together with the addition of a small brick building outside, will be sufficient for the purposes of the Meteorological Committee. When this building is completed it will receive all the moveable iron at present in the Observatory; this arrangement will at the same time set free the present workshop, additional room being required for the increasing work of the Observatory.

J. P. Gassiot, *Chairman.*

Kew Observatory, 22nd August 1867.

Report of the Parliamentary Committee to the Meeting of the British Association at Dundee, September 1867.

The Parliamentary Committee have the honour to report as follows:—

Your Committee have to express their regret that the Public Schools Bill has again failed to obtain the sanction of the Legislature; but it is a subject for congratulation that the discussions in Parliament and elsewhere, which have followed its introduction, have already borne fruit. The attention of the public appears to have been awakened to the necessity for introducing scientific teaching into our Schools, if we are not willing to sink into a condition of inferiority as regards both intellectual culture and skill in art when compared with foreign nations. The voluntary efforts of the Masters of two of our great schools to add instruction in Natural Science to the ordinary Classical course are deserving of all praise; and some evidence of their suc-

cess may be derived from the interesting fact, disclosed in the able Report of the Committee appointed by the Council of the Association to consider this subject, that some of the boys at Harrow have formed themselves into a voluntary Association for the pursuit of Science.

Your Committee have communicated to the Lord Chancellor the Reports of the Committee on Scientific Evidence in Courts of Law; and his Lordship has promised to consider the subject during the recess.

The Chairman of your Committee has also lately been in communication with the President of the Board of Trade, with the object of prevailing on the Government to amend the unsatisfactory provisions now in force, under the authority of the Merchant Shipping Act, for securing the proper adjustment of the Compasses of the iron-built ships of the Mercantile Marine.

This measure was strongly and ably advocated by the President and Council of the Royal Society, in a correspondence which passed between them and the Board of Trade in 1865, but hitherto without success.

WROTTESLEY, *Chairman*.

31st August, 1867.

RECOMMENDATIONS ADOPTED BY THE GENERAL COMMITTEE AT THE DUNDEE MEETING IN SEPTEMBER 1867.

[When Committees are appointed, the Member first named is regarded as the Secretary, except there is a specific nomination.]

Involving Grants of Money.

That the sum of £600 be placed at the disposal of the Council for maintaining the Establishment of the Kew Observatory.

That the Lunar Committee be reappointed, and consist of Mr. J. Glaisher, Lord Rosse, Lord Wrottesley, Sir J. Herschel, Bart., Professor Phillips, Rev. C. Pritchard, Mr. W. Huggins, Mr. W. De la Rue, Mr. C. Brooke, Rev. T. W. Webb, Mr. J. N. Lockyer, and Mr. W. R. Birt; and that the sum of £120 be placed at their disposal.

That Dr. Joule, Sir W. Thomson, Professor Tait, Mr. Balfour Stewart, and Professor G. C. Foster be a Committee for the purpose of executing a remeasurement of the Dynamical Equivalent of Heat; that Professor Foster be the Secretary, and that the sum of £50 be placed at their disposal for the purpose.

That the Committee for reporting on the Rainfall of the British Isles, consisting of Mr. Glaisher, Lord Wrottesley, Professor Phillips, Mr. G. J. Symons, Mr. J. F. Bateman, Mr. R. W. Mylne, and Mr. T. Hawksley, be reappointed; that Mr. G. J. Symons be the Secretary, and that the sum of £50 be placed at their disposal.

That the Balloon Committee, consisting of Colonel Sykes, Mr. Airy, Lord Wrottesley, Sir David Brewster, Sir J. Herschel, Bart., Dr. Robinson, Mr. Fairbairn, Dr. Tyndall, Dr. W. A. Miller, and Mr. Glaisher, be reappointed for the purpose of ascents, and a further reduction of the observations; and that £50 (remaining undrawn from the last grant) be placed at their disposal.

That a Committee, consisting of Sir W. Thomson, the Astronomer Royal, the Presidents of the Royal and Astronomical Societies, Lord Wrottesley, Mr. W. De la Rue, Professor Stokes, Professor Adams, Professor Price, Pro-

fessor Fuller, Professor Kelland, Professor Rankine, Professor Fischer, Mr. Gassiot, Dr. Robinson, Mr. J. F. Bateman, Mr. J. Oldham, Mr. W. Parkes, Mr. T. Webster, Mr. W. Sissons, Admiral Sir Edward Belcher, K.C.B., and Mr. J. F. Iselin (with power to add to their number), be appointed for the purpose of promoting the extension, improvement, and harmonic analysis of Tidal Observations; that Professor Fuller and Mr. J. F. Iselin be the Secretaries, and that the sum of £100 be placed at their disposal for the purpose.

That Sir William Thomson, Dr. Everett, Sir Charles Lyell, Bart., Principal Forbes, Mr. J. Clerk Maxwell, Professor Phillips, Mr. G. J. Symons, Mr. Balfour Stewart, Professor Ramsay, Mr. Geikie, Mr. Glaisher, Rev. Dr. Graham, Mr. E. W. Binney, Mr. George Maw, and Mr. Pengelly be a Committee for the purpose of investigating the rate of increase of Underground Temperature downwards in various localities of dry land and under water; that Dr. Everett be the Secretary, and that the sum of £50 be placed at their disposal for the purpose.

That the Committee on Luminous Meteors and Aërolites, consisting of Mr. Glaisher, Mr. R. P. Greg, Mr. E. W. Brayley, Mr. Alexander Herschel, and Mr. C. Brooke, be reappointed; that Mr. Herschel be the Secretary, and that the sum of £50 be placed at their disposal for the purpose.

That Dr. Anderson and Mr. Catton be a Committee for the purpose of prosecuting the researches of Mr. Catton on the Synthesis of Organic Acids; and that the sum of £60 be placed at their disposal for the purpose.

That Sir Charles Lyell, Bart., Professor Phillips, Sir John Lubbock, Bart., Mr. John Evans, Mr. Edward Vivian, Mr. William Pengelly, and Mr. George Busk be a Committee for the purpose of continuing the exploration of Kent's Cavern, Torquay; that Mr. Pengelly be the Secretary, and that the sum of £150 be placed at their disposal for the purpose.

That Mr. W. S. Mitchell, Mr. Robert Etheridge, Professor J. Morris, and Mr. G. Maw be a Committee for the purpose of investigating the Leaf-beds of the Lower Bagshot Series of the Hampshire Basin; that Mr. Mitchell be the Secretary, and that the sum of £50 be placed at their disposal for the purpose.

That Dr. P. M. Duncan and Mr. Henry Woodward be requested to Report on the British Fossil Corals; and that the sum of £50 be placed at their disposal for the purpose.

That Mr. C. Moore, the Rev. L. Jenyns, and the Rev. H. H. Winwood be a Committee for the purpose of investigating the veins containing Organic Remains which occur in the Mountain Limestone of the Mendips and elsewhere; that Mr. Moore be the Secretary; that the sum of £40 be placed at their disposal for the purpose, and that the objects of interest found shall be disposed in a manner satisfactory to the Council of the Association.

Dr. Bryce, Sir W. Thomson, Mr. D. Milne-Home, and Mr. Macfarlane be requested to resume the researches on Scottish Earthquakes; that Dr. Bryce be the Secretary, and that the sum of £35 be placed at their disposal for the purpose.

That Mr. Henry Woodward, Professor Phillips, and Mr. C. Spence Bate be a Committee for the purpose of continuing their investigations on the Fossil Crustacea; and that the sum of £25 be placed at their disposal for the purpose.

That Professor Phillips, Professor Huxley, and Mr. H. G. Seeley be a Committee for the purpose of drawing up a Report on the present state of our knowledge of Secondary Reptiles, Pterodactyles, and Birds; and that the sum of £50 be placed at their disposal for the purpose.

That Mr. Gwyn Jeffreys, Mr. R. M^cAndrew, the Rev. A. Merle Norman, Mr. E. Walker, Dr. W. C. M^cIntosh, and Mr. E. Ray Lankester be a Committee for the purpose of continuing the investigation of the British Marine Invertebrate Fauna by means of the dredge; that Mr. Gwyn Jeffreys be the Secretary, and that the sum of £100 be placed at their disposal for the purpose.

That Sir John Lubbock, Bart., Mr. H. T. Stainton, and the Rev. H. B. Tristram be a Committee for the purpose of preparing a record of the progress of Zoology in the year 1867; that Sir John Lubbock be the Secretary, and that the sum of £100 be placed at their disposal for the purpose.

That Mr. C. Spence Bate, Mr. Couch, Sir John Lubbock, Bart., Mr. Gwyn Jeffreys, and Mr. Cornish be a Committee for the purpose of exploring the Fauna of the south coast of Devon and Cornwall; that Mr. C. Spence Bate be the Secretary, and that the sum of £30 be placed at their disposal for the purpose.

That Mr. G. Busk and Mr. W. Carruthers be a Committee for the purpose of carrying on investigations on Fossil Flora; that Mr. Carruthers be the Secretary, and that the sum of £25 be placed at their disposal for the purpose.

That Mr. E. Ray Lankester, Mr. Charles Stewart, and Dr. Arthur Gamgee be a Committee for the purpose of investigating Animal Substances with the Spectroscope; that Mr. E. Ray Lankester be the Secretary, and that the sum of £15 be placed at their disposal for the purpose.

That Dr. Bennett, Dr. Christison, Dr. Rogers, Dr. Arthur Gamgee, Dr. W. Rutherford, and Dr. Frazer be a Committee for the purpose of carrying on investigations to determine the action of Mercury on the Secretion of Bile; that Dr. Bennett be the Secretary, and that the sum of £25 be placed at their disposal for the purpose.

That Dr. B. W. Richardson, Professor Humphry, and Dr. Sharpey be a Committee for the purpose of continuing the investigations on the physiological action of the Methyl Series and allied organic compounds; and that the sum of £25 be placed at their disposal for the purpose.

That Sir R. I. Murchison, Bart., Dr. J. D. Hooker, Captain Sherard Osborn, and Mr. C. R. Markham be a Committee for the purpose of promoting the exploration of the interior of Greenland, now in prosecution by Mr. Edward Whymper; that Mr. C. R. Markham be the Secretary, and that the sum of £100 be placed at their disposal for the purpose.

That the Metric Committee be reappointed for the purpose of diffusing knowledge of the relations amongst systems of Moneys, Weights, and Measures, such Committee to consist of Sir John Bowring, The Right Hon. C. B. Adderley, M.P., Mr. Samuel Brown, Mr. W. Ewart, M.P., Capel H. Berger, Dr. Farr, Mr. Frank P. Fellows, Professor Frankland, Professor Hennessy, Mr. James Heywood, Sir Robert Kane, Professor Leone Levi, Professor W. A. Miller, Professor Rankine, Mr. C. W. Siemens, Colonel Sykes, M.P., Professor A. W. Williamson, Lord Wrottesley, Mr. James Yates, Dr. George Glover, Mr. Joseph Whitworth, Mr. J. R. Napier, Mr. H. Dircks, Mr. J. V. N. Bazalgette, Mr. W. Smith, Mr. W. Fairbairn, and Mr. John Robinson; that Professor Leone Levi be the Secretary, and that the sum of £50 be placed at their disposal for the purpose.

That the Committee, consisting of Mr. J. Scott Russell, Mr. T. Hawksley, Mr. J. R. Napier, Mr. William Fairbairn, and Professor W. J. M. Rankine, to analyze and condense the information contained in the Reports of the "Steam-ship Performance" Committee and other sources of information on the same subject, with power to employ paid calculators or assistants, if ne-

cessary, be reappointed; and that the sum of £100 be placed at their disposal for the purpose.

That the Committee, consisting of Mr. W. Fairbairn and Mr. Tait, for continuing experiments with a view to test the improvements in the manufacture of Iron and Steel, be reappointed; and that the sum of £100 be placed at their disposal for the purpose.

Applications for Reports and Researches not involving Grants of Money.

That the Committee on Electrical Standards, consisting of Professor Williamson, Professor Wheatstone, Professor Sir W. Thomson, Professor W. A. Miller, Dr. A. Matthiessen, Mr. Fleeming Jenkin, Sir Charles Bright, Mr. J. Clerk Maxwell, Mr. C. W. Siemens, Mr. Balfour Stewart, Dr. Joule, Mr. C. F. Varley, Mr. G. C. Foster, and Mr. C. Hockin, be reappointed; and that Mr. Fleeming Jenkin be the Secretary.

That Professor Stokes be requested to continue his Researches on Physical Optics.

That Mr. E. J. Lowe, Mr. Glaisher, Dr. Moffat, Mr. C. Brooke, Dr. Andrews, and Dr. B. Ward Richardson be a Committee for the purpose of promoting accurate Meteorological Observations of Ozone; and that Mr. Lowe be the Secretary.

That Dr. Tyndall, Dr. Lyon Playfair, Dr. Odling, Rev. C. Pritchard, Professor Kelland, Professor W. A. Miller, and Professor Foster be a Committee for the purpose of inquiring into the present methods of teaching the elements of Dynamics, Experimental Physics, and Chemistry in schools of various classes, and of suggesting the best means of promoting this object in accordance with the Recommendations of the Report of the Committee appointed by the Council; and that Professor Foster and Dr. Odling be the Secretaries.

That Dr. Matthiessen be requested to continue his researches on the Chemical Constitution of Cast Iron.

That Mr. Thomas Fairley be requested to continue his researches on Polycyanides of the Organic Radicals.

That the Committee on Scientific Evidence in Courts of Law, consisting of the Rev. W. V. Harcourt, Professor Williamson, The Right. Hon. J. Napier, Mr. W. Tite, Professor Christison, Dr. Tyndall, Mr. James Heywood, Mr. J. F. Bateman, Mr. Thomas Webster, Sir Benjamin Brodie, Bart., and Professor W. A. Miller (with power to add to their number), be reappointed; and that Professor Williamson be the Secretary.

That the Patent Law Committee be reappointed, such Committee to consist of Mr. Thomas Webster, Q.C., Sir W. G. Armstrong, Mr. J. F. Bateman, Mr. W. Fairbairn, Mr. John Hawkshaw, Mr. J. Scott Russell, Mr. H. Dircks, Mr. J. V. N. Bazalgette, Professor Rankine, and Mr. P. Le Neve Foster, with power to add to their number.

That a Committee, consisting of the Duke of Buccleuch, the Rev. Patrick Bell, Mr. David Greig, Mr. J. Oldham, Professor Rankine, Mr. William Smith, Mr. Harold Littledale, The Earl of Caithness, and Mr. Robert Neilson, be appointed to prepare a Report on Agricultural Machinery; and that Messrs. J. P. Smith and P. Le Neve Foster be the Secretaries.

That a Committee, consisting of Admiral Sir Edward Belcher, Mr. J. Oldham, Mr. J. R. Napier, Mr. George Fawcus, Mr. William Smith, and Mr. J. Sissons, be appointed to Report on the Regulations affecting the safety of Merchant Ships and their Passengers.

Involving Application to Government.

That the President of the Association be requested to communicate the Report of the Committee appointed by the Council to consider the best means for promoting Scientific Education in Schools, to the President of the Privy Council and to the Parliamentary Committee on the part of the Association; and that the General Officers be authorized to take steps to give publicity to the Report.

That Sir Bartle Frere, Sir Arthur Phayre, Colonel R. Strachey, Colonel Yule, Sir Proby Cautley, Mr. W. Spottiswoode, Dr. J. D. Hooker, and Sir John Lubbock be a Committee for the purpose of representing to the Secretary of State for India the great and urgent importance of adopting active measures to obtain reports on the physical form, manners, customs, &c. of the indigenous population of India, and especially of those tribes which are still in the habit of erecting Megalithic monuments; and that Dr. J. D. Hooker be the Secretary.

That General Sir Andrew S. Waugh, Sir Arthur Phayre, General G. Balfour, General Sir Vincent Eyre, Captain Sherard Osborn, Mr. George Campbell, and Dr. Thomas Thomson be a Committee for the purpose of waiting on the Secretary of State for India to represent the desirability of an exploration being made of the district between the Burhampooter, the Upper Irrawaddy, and the Yang-tze-Kiang, with a view to a route being established between the navigable parts of these rivers; and that Dr. Thomas Thomson be the Secretary.

That Sir Roderick Murchison, Bart., Admiral Erasmus Ommanney, Admiral Collinson, Admiral Sir E. Belcher, Captain Sherard Osborn, Captain Allen Young, and Mr. C. R. Markham be a Committee for the purpose of representing to Her Majesty's Government the desirability of their undertaking an exploration of the area around the North Pole; and that Mr. C. R. Markham be the Secretary.

Communications to be printed in extenso *in the Annual Report of the Association.*

That Mr. C. Meldrum's paper, "On the Meteorology of the Mauritius," be printed *in extenso* among the Reports.

That Mr. I. Lowthian Bell's paper, "On the present state of the Manufacture of Iron in Britain, and its position as compared with that of some other countries," be printed in full in the Report of the Association.

That Mr. Mitchell's paper, "On the Highland Railways," be printed at length amongst the Reports.

Resolved that Resolutions:—

(1) Relating to the continuation of Storm Signals,

(2) The introduction of the knowledge of the Metric System into Government Schools,

(3) Natural-History Collections in the British Museum,

(4) The pollution of rivers, and the preservation of Salmon Fisheries,

be referred to the Council of the Association.

Synopsis of Grants of Money appropriated to Scientific Purposes by the General Committee at the Dundee Meeting in September 1867. *The names of the Members who would be entitled to call on the General Treasurer for the respective Grants are prefixed.*

	£	s.	d.
Kew Observatory.			
Maintaining the Establishment of Kew Observatory	600	0	0
Mathematics and Physics.			
*Glaisher, Mr.—Lunar Committee	120	0	0
Joule, Dr.—Remeasurement of the Dynamical Equivalent of Heat	50	0	0
*Glaisher, Mr.—British Rainfall	50	0	0
*Sykes, Colonel.—Balloon Committee (renewed)	50	0	0
Thomson, Professor Sir W.—Tidal Observations	100	0	0
Thomson, Professor Sir W.—Underground Temperature	50	0	0
*Glaisher, Mr.—Luminous Meteors	50	0	0
Chemistry.			
*Anderson, Dr.—Synthesis of Organic Acids	60	0	0
Geology.			
*Lyell, Sir C., Bart.—Kent's Cavern Investigation	150	0	0
Mitchell, Mr. W. S.—Leaf-beds of the Lower Bagshot series	50	0	0
Duncan, Dr. P. M.—British Fossil Corals	50	0	0
Moore, Mr. C.—Veins containing Organic Remains in the Mountain Limestone	40	0	0
Bryce, Dr.—Scottish Earthquakes	35	0	0
*Woodward, Mr. H.—Fossil Crustacea (renewed)	25	0	0
*Phillips, Professor.—Secondary Reptiles, Pterodactyles, and Birds	50	0	0
Biology.			
Jeffreys, Mr. J. Gwyn.—British Marine Invertebrate Fauna	100	0	0
Lubbock, Sir J., Bart.—The Record of the Progress of Zoology	100	0	0
Bate, Mr. C. Spence.—Fauna of the South Coast of Devon and Cornwall	30	0	0
Busk, Mr. G.—Fossil Flora	25	0	0
Lankester, Mr. E. Ray.—Investigation of Animal Substances with the Spectroscope	15	0	0
Bennett, Dr.—Action of Mercury on the Secretion of Bile	25	0	0
*Richardson, Dr.—Physiological Action of the Methyl Series	25	0	0
Geography and Ethnology.			
Murchison, Sir R. I., Bart.—Greenland Exploration	100	0	0
Statistics and Economic Science.			
*Bowring, Sir J.—Metrical Committee	50	0	0
Mechanics.			
*Russell, Mr. J. Scott.—Analysis of Reports on Steam-ship Performance	100	0	0
*Fairbairn, Mr. W.—Manufacture of Iron and Steel	100	0	0
Total	2200	0	0

* Reappointed.

General Statement of Sums which have been paid on Account of Grants for Scientific Purposes.

	£	s.	d.
1834.			
Tide Discussions	20	0	0
1835.			
Tide Discussions	62	0	0
British Fossil Ichthyology	105	0	0
	£167	0	0
1836.			
Tide Discussions	163	0	0
British Fossil Ichthyology	105	0	0
Thermometric Observations, &c.	50	0	0
Experiments on long-continued Heat	17	1	0
Rain-Gauges	9	13	0
Refraction Experiments	15	0	0
Lunar Nutation	60	0	0
Thermometers	15	6	0
	£434	14	0
1837.			
Tide Discussions	284	1	0
Chemical Constants	24	13	6
Lunar Nutation	70	0	0
Observations on Waves	100	12	0
Tides at Bristol	150	0	0
Meteorology and Subterranean Temperature	89	5	0
Vitrification Experiments	150	0	0
Heart Experiments	8	4	6
Barometric Observations	30	0	0
Barometers	11	18	6
	£918	14	6
1838.			
Tide Discussions	29	0	0
British Fossil Fishes	100	0	0
Meteorological Observations and Anemometer (construction)	100	0	0
Cast Iron (Strength of)	60	0	0
Animal and Vegetable Substances (Preservation of)	19	1	10
Railway Constants	41	12	10
Bristol Tides	50	0	0
Growth of Plants	75	0	0
Mud in Rivers	3	6	6
Education Committee	50	0	0
Heart Experiments	5	3	0
Land and Sea Level	267	8	7
Subterranean Temperature	8	6	0
Steam-vessels	100	0	0
Meteorological Committee	31	9	5
Thermometers	16	4	0
	£956	12	2
1839.			
Fossil Ichthyology	110	0	0
Meteorological Observations at Plymouth	63	10	0
Mechanism of Waves	144	2	0
Bristol Tides	35	18	6
Meteorology and Subterranean Temperature	21	11	0
Vitrification Experiments	9	4	7
Cast Iron Experiments	100	0	0
Railway Constants	28	7	2
Land and Sea Level	274	1	4
Steam-vessels' Engines	100	0	0
Stars in Histoire Céleste	331	18	6
Stars in Lacaille	11	0	0
Stars in R.A.S. Catalogue	6	16	6
Animal Secretions	10	10	0
Steam-engines in Cornwall	50	0	0
Atmospheric Air	16	1	0
Cast and Wrought Iron	40	0	0
Heat on Organic Bodies	3	0	0
Gases on Solar Spectrum	22	0	0
Hourly Meteorological Observations, Inverness and Kingussie	49	7	8
Fossil Reptiles	118	2	9
Mining Statistics	50	0	0
	£1595	11	0
1840.			
Bristol Tides	100	0	0
Subterranean Temperature	13	13	6
Heart Experiments	18	19	0
Lungs Experiments	8	13	0
Tide Discussions	50	0	0
Land and Sea Level	6	11	1
Stars (Histoire Céleste)	242	10	0
Stars (Lacaille)	4	15	0
Stars (Catalogue)	264	0	0
Atmospheric Air	15	15	0
Water on Iron	10	0	0
Heat on Organic Bodies	7	0	0
Meteorological Observations	52	17	6
Foreign Scientific Memoirs	112	1	6
Working Population	100	0	0
School Statistics	50	0	0
Forms of Vessels	184	7	0
Chemical and Electrical Phenomena	40	0	0
Meteorological Observations at Plymouth	80	0	0
Magnetical Observations	185	13	9
	£1546	16	4
1841.			
Observations on Waves	30	0	0
Meteorology and Subterranean Temperature	8	8	0
Actinometers	10	0	0
Earthquake Shocks	17	7	0
Acrid Poisons	6	0	0
Veins and Absorbents	3	0	0
Mud in Rivers	5	0	0
Marine Zoology	15	12	8
Skeleton Maps	20	0	0
Mountain Barometers	6	18	6
Stars (Histoire Céleste)	185	0	0

	£	s.	d.
Stars (Lacaille)	79	5	0
Stars (Nomenclature of)	17	19	6
Stars (Catalogue of)	40	0	0
Water on Iron	50	0	0
Meteorological Observations at Inverness	20	0	0
Meteorological Observations (reduction of)	25	0	0
Fossil Reptiles	50	0	0
Foreign Memoirs	62	0	0
Railway Sections	38	1	6
Forms of Vessels	193	12	0
Meteorological Observations at Plymouth	55	0	0
Magnetical Observations	61	18	8
Fishes of the Old Red Sandstone	100	0	0
Tides at Leith	50	0	0
Anemometer at Edinburgh	69	1	10
Tabulating Observations	9	6	3
Races of Men	5	0	0
Radiate Animals	2	0	0
	£1235	10	11

1842.

	£	s.	d.
Dynamometric Instruments	113	11	2
Anoplura Britanniæ	52	12	0
Tides at Bristol	59	8	0
Gases on Light	30	14	7
Chronometers	26	17	6
Marine Zoology	1	5	0
British Fossil Mammalia	100	0	0
Statistics of Education	20	0	0
Marine Steam-vessels' Engines	28	0	0
Stars (Histoire Céleste)	59	0	0
Stars (Brit. Assoc. Cat. of)	110	0	0
Railway Sections	161	10	0
British Belemnites	50	0	0
Fossil Reptiles (publication of Report)	210	0	0
Forms of Vessels	180	0	0
Galvanic Experiments on Rocks	5	8	6
Meteorological Experiments at Plymouth	68	0	0
Constant Indicator and Dynamometric Instruments	90	0	0
Force of Wind	10	0	0
Light on Growth of Seeds	8	0	0
Vital Statistics	50	0	0
Vegetative Power of Seeds	8	1	11
Questions on Human Race	7	9	0
	£1449	17	8

1843.

	£	s.	d.
Revision of the Nomenclature of Stars	2	0	0
Reduction of Stars, British Association Catalogue	25	0	0
Anomalous Tides, Frith of Forth	120	0	0
Hourly Meteorological Observations at Kingussie and Inverness	77	12	8
Meteorological Observations at Plymouth	55	0	0
Whewell's Meteorological Anemometer at Plymouth	10	0	0
Meteorological Observations, Osler's Anemometer at Plymouth	20	0	0
Reduction of Meteorological Observations	30	0	0
Meteorological Instruments and Gratuities	39	6	0
Construction of Anemometer at Inverness	56	12	2
Magnetic Cooperation	10	8	10
Meteorological Recorder for Kew Observatory	50	0	0
Action of Gases on Light	18	16	1
Establishment at Kew Observatory, Wages, Repairs, Furniture and Sundries	133	4	7
Experiments by Captive Balloons	81	8	0
Oxidation of the Rails of Railways	20	0	0
Publication of Report on Fossil Reptiles	40	0	0
Coloured Drawings of Railway Sections	147	18	3
Registration of Earthquake Shocks	30	0	0
Report on Zoological Nomenclature	10	0	0
Uncovering Lower Red Sandstone near Manchester	4	4	6
Vegetative Power of Seeds	5	3	8
Marine Testacea (Habits of)	10	0	0
Marine Zoology	10	0	0
Marine Zoology	2	14	11
Preparation of Report on British Fossil Mammalia	100	0	0
Physiological Operations of Medicinal Agents	20	0	0
Vital Statistics	36	5	8
Additional Experiments on the Forms of Vessels	70	0	0
Additional Experiments on the Forms of Vessels	100	0	0
Reduction of Experiments on the Forms of Vessels	100	0	0
Morin's Instrument and Constant Indicator	69	14	10
Experiments on the Strength of Materials	60	0	0
	£1565	10	2

1844.

	£	s.	d.
Meteorological Observations at Kingussie and Inverness	12	0	0
Completing Observations at Plymouth	35	0	0
Magnetic and Meteorological Cooperation	25	8	4
Publication of the British Association Catalogue of Stars	35	0	0
Observations on Tides on the East coast of Scotland	100	0	0
Revision of the Nomenclature of Stars 1842	2	9	6
Maintaining the Establishment in Kew Observatory	117	17	3
Instruments for Kew Observatory	56	7	3

	£	s.	d.
Influence of Light on Plants......	10	0	0
Subterraneous Temperature in Ireland	5	0	0
Coloured Drawings of Railway Sections	15	17	6
Investigation of Fossil Fishes of the Lower Tertiary Strata ...	100	0	0
Registering the Shocks of Earthquakes 1842	23	11	10
Structure of Fossil Shells	20	0	0
Radiata and Mollusca of the Ægean and Red Seas.....1842	100	0	0
Geographical Distributions of Marine Zoology............1842	0	10	0
Marine Zoology of Devon and Cornwall	10	0	0
Marine Zoology of Corfu	10	0	0
Experiments on the Vitality of Seeds	9	0	3
Experiments on the Vitality of Seeds 1842	8	7	3
Exotic Anoplura	15	0	0
Strength of Materials	100	0	0
Completing Experiments on the Forms of Ships	100	0	0
Inquiries into Asphyxia	10	0	0
Investigations on the Internal Constitution of Metals	50	0	0
Constant Indicator and Morin's Instrument 1842	10	3	6
	£981	12	8

1845.

	£	s.	d.
Publication of the British Association Catalogue of Stars	351	14	6
Meteorological Observations at Inverness	30	18	11
Magnetic and Meteorological Cooperation	16	16	8
Meteorological Instruments at Edinburgh	18	11	9
Reduction of Anemometrical Observations at Plymouth	25	0	0
Electrical Experiments at Kew Observatory	43	17	8
Maintaining the Establishment in Kew Observatory	149	15	0
For Kreil's Barometrograph	25	0	0
Gases from Iron Furnaces	50	0	0
The Actinograph	15	0	0
Microscopic Structure of Shells...	20	0	0
Exotic Anoplura 1843	10	0	0
Vitality of Seeds..............1843	2	0	7
Vitality of Seeds..............1844	7	0	0
Marine Zoology of Cornwall......	10	0	0
Physiological Action of Medicines	20	0	0
Statistics of Sickness and Mortality in York	20	0	0
Earthquake Shocks 1843	15	14	8
	£830	9	9

1846.

	£	s.	d.
British Association Catalogue of Stars 1844	211	15	0
Fossil Fishes of the London Clay	100	0	0
Computation of the Gaussian Constants for 1839...............	50	0	0
Maintaining the Establishment at Kew Observatory	146	16	7
Strength of Materials...............	60	0	0
Researches in Asphyxia............	6	16	2
Examination of Fossil Shells......	10	0	0
Vitality of Seeds 1844	2	15	10
Vitality of Seeds 1845	7	12	3
Marine Zoology of Cornwall......	10	0	0
Marine Zoology of Britain	10	0	0
Exotic Anoplura 1844	25	0	0
Expenses attending Anemometers	11	7	6
Anemometers' Repairs	2	3	6
Atmospheric Waves	3	3	3
Captive Balloons 1844	8	19	3
Varieties of the Human Race 1844	7	6	3
Statistics of Sickness and Mortality in York	12	0	0
	£685	16	0

1847.

	£	s.	d.
Computation of the Gaussian Constants for 1839	50	0	0
Habits of Marine Animals	10	0	0
Physiological Action of Medicines	20	0	0
Marine Zoology of Cornwall ...	10	0	0
Atmospheric Waves	6	9	3
Vitality of Seeds	4	7	7
Maintaining the Establishment at Kew Observatory	107	8	6
	£208	5	4

1848.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	171	15	11
Atmospheric Waves	3	10	9
Vitality of Seeds	9	15	0
Completion of Catalogues of Stars	70	0	0
On Colouring Matters	5	0	0
On Growth of Plants...............	15	0	0
	£275	1	8

1849.

	£	s.	d.
Electrical Observations at Kew Observatory	50	0	0
Maintaining Establishment at ditto	76	2	5
Vitality of Seeds	5	8	1
On Growth of Plants...............	5	0	0
Registration of Periodical Phenomena	10	0	0
Bill on account of Anemometrical Observations	13	9	0
	£159	19	6

1850.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	255	18	0
Transit of Earthquake Waves ..	50	0	0

	£	s.	d.
Periodical Phenomena	15	0	0
Meteorological Instrument, Azores	25	0	0
	£345	18	0

1851.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (includes part of grant in 1849)	309	2	2
Theory of Heat	20	1	1
Periodical Phenomena of Animals and Plants	5	0	0
Vitality of Seeds	5	6	4
Influence of Solar Radiation	30	0	0
Ethnological Inquiries	12	0	0
Researches on Annelida	10	0	0
	£391	9	7

1852.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (including balance of grant for 1850)	233	17	8
Experiments on the Conduction of Heat	5	2	9
Influence of Solar Radiations	20	0	0
Geological Map of Ireland	15	0	0
Researches on the British Annelida	10	0	0
Vitality of Seeds	10	6	2
Strength of Boiler Plates	10	0	0
	£304	6	7

1853.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	165	0	0
Experiments on the Influence of Solar Radiation	15	0	0
Researches on the British Annelida	10	0	0
Dredging on the East Coast of Scotland	10	0	0
Ethnological Queries	5	0	0
	£205	0	0

1854.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (including balance of former grant)	330	15	4
Investigations on Flax	11	0	0
Effects of Temperature on Wrought Iron	10	0	0
Registration of Periodical Phenomena	10	0	0
British Annelida	10	0	0
Vitality of Seeds	5	2	3
Conduction of Heat	4	2	0
	£380	19	7

1855.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	425	0	0
Earthquake Movements	10	0	0
Physical Aspect of the Moon	11	8	5
Vitality of Seeds	10	7	11
Map of the World	15	0	0
Ethnological Queries	5	0	0
Dredging near Belfast	4	0	0
	£480	16	4

1856.

	£	s.	d.
Maintaining the Establishment at Kew Observatory:— 1854......£ 75 0 0; 1855......£500 0 0	575	0	0
Strickland's Ornithological Synonyms	100	0	0
Dredging and Dredging Forms	9	13	9
Chemical Action of Light	20	0	0
Strength of Iron Plates	10	0	0
Registration of Periodical Phenomena	10	0	0
Propagation of Salmon	10	0	0
	£734	13	9

1857.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	350	0	0
Earthquake Wave Experiments	40	0	0
Dredging near Belfast	10	0	0
Dredging on the West Coast of Scotland	10	0	0
Investigations into the Mollusca of California	10	0	0
Experiments on Flax	5	0	0
Natural History of Madagascar	20	0	0
Researches on British Annelida	25	0	0
Report on Natural Products imported into Liverpool	10	0	0
Artificial Propagation of Salmon	10	0	0
Temperature of Mines	7	8	0
Thermometers for Subterranean Observations	5	7	4
Life-Boats	5	0	0
	£507	15	4

1858.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Earthquake Wave Experiments	25	0	0
Dredging on the West Coast of Scotland	10	0	0
Dredging near Dublin	5	0	0
Vitality of Seeds	5	5	0
Dredging near Belfast	18	13	2
Report on the British Annelida	25	0	0
Experiments on the production of Heat by Motion in Fluids	20	0	0
Report on the Natural Products imported into Scotland	10	0	0
	£618	18	2

1859.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Dredging near Dublin	15	0	0
Osteology of Birds	50	0	0
Irish Tunicata	5	0	0
Manure Experiments	20	0	0
British Medusidæ	5	0	0
Dredging Committee	5	0	0
Steam-vessels' Performance	5	0	0
Marine Fauna of South and West of Ireland	10	0	0
Photographic Chemistry	10	0	0
Lanarkshire Fossils	20	0	1
Balloon Ascents	39	11	0
	£684	11	1

1860.	£	s.	d.
Maintaining the Establishment of Kew Observatory	500	0	0
Dredging near Belfast	16	6	0
Dredging in Dublin Bay	15	0	0
Inquiry into the Performance of Steam-vessels	124	0	0
Explorations in the Yellow Sandstone of Dura Den	20	0	0
Chemico-mechanical Analysis of Rocks and Minerals	25	0	0
Researches on the Growth of Plants	10	0	0
Researches on the Solubility of Salts	30	0	0
Researches on the Constituents of Manures	25	0	0
Balance of Captive Balloon Accounts	1	13	6
	£1241	7	0

1861.	£	s.	d.
Maintaining the Establishment of Kew Observatory	500	0	0
Earthquake Experiments	25	0	0
Dredging North and East Coasts of Scotland	23	0	0
Dredging Committee:— 1860 ...... £50 0 0; 1861 ...... £22 0 0	72	0	0
Excavations at Dura Den	20	0	0
Solubility of Salts	20	0	0
Steam-vessel Performance	150	0	0
Fossils of Lesmahago	15	0	0
Explorations at Uriconium	20	0	0
Chemical Alloys	20	0	0
Classified Index to the Transactions	100	0	0
Dredging in the Mersey and Dee	5	0	0
Dip Circle	30	0	0
Photoheliographic Observations	50	0	0
Prison Diet	20	0	0
Gauging of Water	10	0	0
Alpine Ascents	6	5	1
Constituents of Manures	25	0	0
	£1111	5	10

1862.	£	s.	d.
Maintaining the Establishment of Kew Observatory	500	0	0
Patent Laws	21	6	0
Mollusca of N.-W. America	10	0	0
Natural History by Mercantile Marine	5	0	0
Tidal Observations	25	0	0
Photoheliometer at Kew	40	0	0
Photographic Pictures of the Sun	150	0	0
Rocks of Donegal	25	0	0
Dredging Durham and Northumberland	25	0	0
Connexion of Storms	20	0	0
Dredging North-East Coast of Scotland	6	9	6
Ravages of Teredo	3	11	0
Standards of Electrical Resistance	50	0	0
Railway Accidents	10	0	0
Balloon Committee	200	0	0
Dredging Dublin Bay	10	0	0
Dredging the Mersey	5	0	0
Prison Diet	20	0	0
Gauging of Water	12	10	0
Steamships' Performance	150	0	0
Thermo-Electric Currents	5	0	0
	£1293	16	6

1863.	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Balloon Committee deficiency	70	0	0
Balloon Ascents (other expenses)	25	0	0
Entozoa	25	0	0
Coal Fossils	20	0	0
Herrings	20	0	0
Granites of Donegal	5	0	0
Prison Diet	20	0	0
Vertical Atmospheric Movements	13	0	0
Dredging Shetland	50	0	0
Dredging North-east coast of Scotland	25	0	0
Dredging Northumberland and Durham	17	3	10
Dredging Committee superintendence	10	0	0
Steamship Performance	100	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Volcanic Temperature	100	0	0
Bromide of Ammonium	8	0	0
Electrical Standards	100	0	0
—— Construction and distribution	40	0	0
Luminous Meteors	17	0	0
Kew Additional Buildings for Photoheliograph	100	0	0
Thermo-Electricity	15	0	0
Analysis of Rocks	8	0	0
Hydroids	10	0	0
	£1608	3	10

1864.	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Coal Fossils	20	0	0
Vertical Atmospheric Movements	20	0	0
Dredging Shetland	75	0	0
Dredging Northumberland	25	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Standards of Electric Resistance	100	0	0
Analysis of Rocks	10	0	0
Hydroida	10	0	0
Askham's Gift	50	0	0
Nitrite of Amyle	10	0	0
Nomenclature Committee	5	0	0
Rain-Gauges	19	15	8
Cast Iron Investigation	20	0	0
Tidal Observations in the Humber	50	0	0
Spectral Rays	45	0	0
Luminous Meteors	20	0	0
	£1289	15	8

1865.	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Balloon Committee	100	0	0
Hydroida	13	0	0
Rain-Gauges	30	0	0
Tidal Observations in the Humber	6	8	0
Hexylic Compounds	20	0	0
Amyl Compounds	20	0	0
Irish Flora	25	0	0
American Mollusca	3	9	0
Organic Acids	20	0	0
Lingula Flags Excavation	10	0	0
Eurypterus	50	0	0
Electrical Standards	100	0	0
Malta Caves Researches	30	0	0
Oyster Breeding	25	0	0
Gibraltar Caves Researches	150	0	0
Kent's Hole Excavations	100	0	0
Moon's Surface Observations	35	0	0
Marine Fauna	25	0	0
Dredging Aberdeenshire	25	0	0
Dredging Channel Islands	50	0	0
Zoological Nomenclature	5	0	0
Resistance of Floating Bodies in Water	100	0	0
Bath Waters Analysis	8	10	0
Luminous Meteors	40	0	0
	£1591	7	10

1866.	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Lunar Committee	64	13	4
Balloon Committee	50	0	0
Metrical Committee	50	0	0
British Rainfall	50	0	0
Kilkenny Coal Fields	16	0	0
Alum Bay Fossil Leaf-Bed	15	0	0
Luminous Meteors	50	0	0
Lingula Flags Excavation	20	0	0
Chemical Constitution of Cast Iron	50	0	0
Amyl Compounds	25	0	0
Electrical Standards	100	0	0
Malta Caves Exploration	30	0	0
Kent's Hole Exploration	200	0	0
Marine Fauna, &c., Devon and Cornwall	25	0	0
Dredging Aberdeenshire Coast	25	0	0
Dredging Hebrides Coast	50	0	0
Dredging the Mersey	5	0	0
Resistance of Floating Bodies in Water	50	0	0
Polycyanides of Organic Radicals	20	0	0
Rigor Mortis	10	0	0
Irish Annelida	15	0	0
Catalogue of Crania	50	0	0
Didine Birds of Mascarene Islands	50	0	0
Typical Crania Researches	30	0	0
Palestine Exploration Fund	100	0	0
	£1750	13	4

1867.	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Meteorological Instruments, Palestine	50	0	0
Lunar Committee	120	0	0
Metrical Committee	30	0	0
Kent's Hole Explorations	100	0	0
Palestine Explorations	50	0	0
Insect Fauna, Palestine	30	0	0
British Rainfall	50	0	0
Kilkenny Coal Fields	25	0	0
Alum Bay Fossil Leaf-Bed	25	0	0
Luminous Meteors	50	0	0
Bournemouth, &c. Leaf-Beds	30	0	0
Dredging, Shetland	75	0	0
Steam-ship Reports Condensation	100	0	0
Electrical Standards	100	0	0
Ethyle and Methyle series	25	0	0
Fossil Crustacea	25	0	0
Sound under Water	24	4	0
North Greenland Fauna	75	0	0
Do. Plant Beds	100	0	0
Iron and Steel Manufacture	25	0	0
Patent Laws	30	0	0
	£1739	4	0

Extracts from Resolutions of the General Committee.

Committees and individuals, to whom grants of money for scientific purposes have been entrusted, are required to present to each following Meeting of the Association a Report of the progress which has been made; with a statement of the sums which have been expended, and the balance which remains disposable on each grant.

Grants of pecuniary aid for scientific purposes from the funds of the Association expire at the ensuing Meeting, unless it shall appear by a Report that the Recommendations have been acted on, or a continuation of them be ordered by the General Committee.

In each Committee, the Member first named is the person entitled to call on the Treasurer, William Spottiswoode, Esq., 50 Grosvenor Place, London, S.W., for such portion of the sum granted as may from time to time be required.

In grants of money to Committees, the Association does not contemplate the payment of personal expenses to the members.

In all cases where additional grants of money are made for the continuation of Researches at the cost of the Association, the sum named shall be deemed to include, as a part of the amount, the specified balance which may remain unpaid on the former grant for the same object.

General Meetings.

On Wednesday Evening, September 4, at 8 P.M., in the Kinnaird Hall, Sir R. I. Murchison, Bart., K.C.B., F.R.S., Vice-President, in the absence of William R. Grove, Esq., M.A., F.R.S., resigned the office of President to His Grace the Duke of Buccleuch, K.G., F.R.S., who took the Chair, and delivered an Address.

On Thursday Evening, September 5, at 8 P.M., a Soirée took place in the Volunteers' Hall.

On Thursday Evening, September 5, in the Kinnaird Hall, Prof. Tyndall, LL.D., F.R.S., delivered a Discourse on "Matter and Force," to the Operative Classes of Dundee.

On Friday Evening, September 6, at 8.30 P.M., in the Kinnaird Hall, Archibald Geikie, Esq., F.R.S., F.G.S., delivered a Discourse on the "Geological Origin of the present Scenery of Scotland."

On Monday Evening, September 9, at 8.30 P.M., in the Kinnaird Hall, Alexander Herschel, Esq., F.R.A.S., delivered a Discourse on "The Present State of Knowledge regarding Meteors and Meteorites."

On Tuesday Evening, September 10, at 8 P.M., a Soirée took place in the Volunteers' Hall.

On Wednesday, September 11, at 3 P.M., the concluding General Meeting took place, when the Proceedings of the General Committee, and the Grants of Money for Scientific purposes, were explained to the Members.

The Meeting was then adjourned to Norwich*.

* The Meeting is appointed to take place on Wednesday, August 19, 1868.

ERRATA IN REPORT OF THE ELECTRICAL STANDARD COMMITTEE FOR 1863.

P. 140, in equation 9, *for* k^2 *read* k.

P. 144, line 19 from top, *for* R *read* R_1.

P. 152, *for* force equal to $\frac{0{\cdot}0002951}{d^2}$ absolute units, or $\frac{0{\cdot}0000239}{d^2}$ gramme weight, *read* force equal to $\frac{0{\cdot}0002951 \times 0{\cdot}0002951}{d^2}$ absolute units, or $\frac{0{\cdot}0000000007053}{d^2}$ gramme weight.

P. 157, in equation 28, $\Theta = \frac{RC^2t}{{\cdot}4157}$, omit the decimal point erroneously put before 4157; and three lines lower, *for* 24·861 and ·4157 *read* 24861 and 4157.

P. 158, *for* By the definition of electrochemical equivalents, E=N *read* Q=N.

REPORTS

ON

THE STATE OF SCIENCE.

REPORTS

ON

THE STATE OF SCIENCE.

Report of the Lunar Committee for Mapping the Surface of the Moon. Drawn up by W. R. Birt, *at the request of the Committee, consisting of* James Glaisher, *F.R.S.*, Lord Rosse, *F.R.S.*, Lord Wrottesley, *F.R.S.*, Sir J. Herschel, *Bart.*, *F.R.S.*, Professor Phillips, *F.R.S.*, Rev. C. Pritchard, *F.R.S.*, W. Huggins, *F.R.S.*, Warren De la Rue, *F.R.S.*, C. Brooke, *F.R.S.*, Rev. T. W. Webb, *F.R.A.S.*, J. N. Lockyer, *F.R.A.S.*, Herr Schmidt, *and* W. R. Birt, *F.R.A.S.*

The Report now presented contains an account of the proceedings of the Lunar Committee during the past Association year. These proceedings have reference to the following subjects:—First, the registration of craters and other visible objects. Secondly, the construction of an outline map. And thirdly, an examination of an alleged change upon the surface of the moon.

The Registration of Objects.—In connexion with this head nothing has transpired during the past year to render necessary any addition to the plan proposed by the Committee in 1865. The mode of registration was treated very fully in the Report presented at Birmingham, and published in the volume of Reports for 1865, pp. 287–300.

The number of objects now registered are as follows:—

514	on	124	Areas in Quadrant		I.
349	„	86	„	„	II.
205	„	57	„	„	III.
557	„	62	„	„	IV.
Total 1625	„	329	„ on the moon's surface.		

The Outline Map.—During the past year the Committee authorized the engraving and printing of Areas IV A^{α} and IV^{ζ}, also the printing of the catalogue of objects inserted on those areas, and the distribution of copies to gentlemen taking part in the work. As the printing was completed, and the issue had commenced before the last Report had gone to press, it was considered advisable, in order to give them greater circulation, to append these areas and catalogue to that Report. They form Appendix III., Report, 1866, pp. 239–280.

The Committee, recognizing the great importance of obtaining *periodical examinations* of the moon's disk, suggested that the entire surface should be divided into subzones of 1° of latitude (Report, 1866, p. 240), and allotted to

gentlemen willing to cooperate in the work. The two areas at present issued embrace 10 degrees of latitude, and the allotment has been so arranged that each *pair* of subzones overlap and dovetail into the adjoining pairs. In Appendix III. to the last Report, the objects in each pair of subzones are specified in the order of their conspicuousness (see Report, 1866, p. 241). The following subzones have been allotted as under:—

Area IVA$^{\alpha}$.

			inches.	
No. 1.	G. J. Walker, Esq., Teignmouth, Devon.	Aperture	$3\frac{3}{4}$,	achr.
„ 2.	D. Smith, Esq., Birmingham.	„	3,	achr.
„ 3.	Mrs. Jackson, Old Brompton.	„	$3\frac{3}{4}$,	achr.
	T. Whitehouse, Esq., West Bromwich.	„	$12\frac{1}{2}$,	achr.
	J. Leigh, Esq., Warrington.	„	$8\frac{1}{8}$,	refl.
„ 4.	F. Bird, Esq., Birmingham.	„	12,	refl.
„ 5.	J. Graham, Esq., Ashton-under-Lyne.	„	$4\frac{1}{4}$,	achr.
„ 6.	Rev. W. O. Williams, Pwllheli, North Wales.	„	$4\frac{1}{16}$,	achr.

Area IVA$^{\zeta}$.

			inches.	
No. 1.	Rev. W. O. Williams, Pwllheli, North Wales.	Aperture	$4\frac{1}{16}$,	achr.
„ 2.	H. Ingall, Esq., Camberwell.	„	4·5,	dial.
„ 3.	C. Grover, Esq., Chesham, Bucks.	„	$6\frac{1}{2}$,	refl.
„ 4.	F. C. Penrose, Esq., Wimbledon.	„	$5\frac{1}{4}$,	achr.
„ 5.	T. Petty, Esq., Deddington, near Oxford.	„	3,	achr.
„ 6.	D. Gill, Esq., Aberdeen.	„	12,	refl.

In addition to the above named, the following gentlemen have kindly offered to make occasional observations, and to examine particular objects:—

		inches.	
J. Buckingham, Esq., Walworth.	Aperture	9 & $21\frac{1}{4}$,	achr.
J. N. Lockyer, Esq., Finchley Road.	„	6,	achr.
H. Barnes, Esq., Holloway.	„	$10\frac{1}{4}$,	refl.
D. A. Freeman, Esq., Upper Tooting, Surrey.	„	$4\frac{1}{2}$,	achr.
W. Huggins, Esq., Upper Tulse Hill.	„	8,	achr.
J. Browning, Esq., Holloway.	„	12,	refl.
E. Crossley, Esq., Halifax.	„	9·3,	achr.
D. M. Webster, Esq., Dundee.	„	7,	achr.
G. Knott, Esq., Cuckfield, Sussex.	„	$7\frac{1}{3}$,	achr.
Rev. W. R. Dawes, Haddenham.	„	8,	achr.
Rev. T. W. Webb, Hardwick, Herefordshire.	„	$9\frac{1}{4}$,	refl.
H. J. Slack, Esq., Camden Square.	„	$6\frac{1}{2}$,	refl.
T. Barneby, Esq., Worcester.	„	9,	achr.
J. Joynson, Esq., Waterloo, Liverpool.	„	6,	achr.
G. Williams, Esq., Liverpool.	„	$4\frac{1}{4}$,	achr.
Capt. Noble, Maresfield, Sussex.	„	4·2,	achr.
C. L. Prince, Esq., Uckfield, Sussex.	„	6·8,	achr.
Rev. J. Simpson, Dysart, Fife.	„	3,	achr.
		4,	refl.

Several returns have been received, but they are not yet in a state fit for publication.

It has been proposed that, previous to publishing any returns that may be made to the Committee, the objects reported by the several observers shall be re-examined by Mr. Birt, or by some other gentleman on behalf of the Committee, with the aid of a telescope of superior power. The annual grant,

which the Committee request may be renewed, is not available for supplying an instrument suitable for this purpose, as it is necessarily expended in carrying on the work of mapping, registration, &c. Nevertheless the Committee hope that aid may be afforded by which this desirable object may be attained, as, by the use of such an instrument, an authority will be given to the work of a kind which it would not otherwise possess.

Alleged Change on the Moon's Surface.—On the 27th of November 1866, the Committee received a communication from Herr Schmidt, Director of the Observatory at Athens, announcing that a remarkable change had taken place in the crater "Linné." The importance of this communication was at once apparent, as bearing in one direction on an interesting question on lunar physics, and in another on the labours of the Committee. Two years ago the Committee urged the necessity of so registering an object that it might ever after, in *all* time, be sufficiently identified by *all* future observers (Report, 1865, p. 294). The announcement of Schmidt suggests a modification; for if a change sufficiently extensive should take place in any object, the condition of which had been definitely settled by more than one observer, it might be difficult to identify it *as the same object,* but the value of the determination of its former condition would be increased, both determinations being equally good. In the particular case of "Linné," it is only in the latter part of 1866, and up to September 1867, that its real state may be regarded as settled upon the testimony of numerous observers, whose observations fairly agree among themselves. With regard to its former state there is some doubt, in consequence of real or supposed inexactitude in previous observations, from which it is difficult to arrive at a conclusion; an earlier observation agreeing (in the opinion of most astronomers) with its present appearance, while others of a later date are irreconcileable with it. In the present state of Selenography a record of its real condition at any particular epoch is so obviously important that nearly the whole of the observations, both early and recent, that have come into the possession of the Committee, are given in an appendix; those not inserted are mere repetitions of similar features.

Herr Tempel's opinion of the round white spots on the moon's surface (analogous to the appearance which Linné now presents) being of interest for the existence of a *chemically warm activity* (Astronomische Nachrichten, No. 1655, translated by W. T. Lynn, B.A., F.R.A.S., Astronomical Register, No. 58, p. 219), demands attention. These spots, which are very numerous, have usually been considered as ground-markings, but as Linné, in 1788, and in 1866–67, presented a similar appearance, they will in future command more attention.

During the past year the Committee have issued three Circulars:—No. I. announcing the change in Linné; No. II. Tables of the periods of visibility of those portions of the surface near the moon's limb periodically concealed by changes of libration; and No. III. a *résumé* of the results of observations of Linné up to June 1867. A portion of this Circular, with additional observations, will be found in the Appendix.

APPENDIX.

Linné.—Observations, early and recent.

Linné is marked A in Lohrmann's Section IV.

1 (*a*). Schroter's observation, 1788.—"Nov. 5, $4^h\ 30^m$ to 8^h (Selenotopographische Fragmente, vol. i. p. 181). Die sechste Bergader kommt von

einer fast dicht an den südlichen Gränzgebirgen befindlichen, verhältlich gezeichneten Einsenkung *u*, streicht nördlich nach *v*, *wo selbst sie wieder eine ohngefähr gleich grosse, aber ganz flache, als ein weisses, sehr kleines rundes Fleckchen erscheinende, etwas ungewisse Einsenkung in sich hat.*"

Translation.—The sixth ridge comes from a depression *u*, situated almost close upon the south boundary mountains, passes northwards towards *v*, *where it again has within it a somewhat uncertain depression of about the same size, but quite flat and resembling a white, very small round spot.*

(*b*). SCHMIDT'S RÉFERENCE TO SCHROTER'S OBSERVATION.—" I. SCHRÖTER, 5. Nov. 1788, Abends, berührte die zunehmende Phase den Ostrand des Mare Serenitatis, so dass die Berge des Caucasus und der nördliche Apennin schon erleuchtet waren. *Schroter* beobachtete diesmal mit 95-maliger Vergrösserung des siebenfussigen Reflectors. Seine Abbildung vom 5. Nov. ist Tab. IX., Band I., der Selenotopographischen Fragmente. Der kleine Crater *v* daselbst entspricht am *nächsten* dem Orte des Linné, keineswegs aber *y*, der jetzt noch sichtbar ist, und noch weniger der dunkle Fleck *g*."

Translation.—I. SCHROTER, 5 Nov. 1788, in the evening, at the increasing phase, the terminator was in contact with the eastern boundary of the Mare Serenitatis, so that the mountains of Caucasus and the northern Apennine were already illuminated. Schroter observed this time with a power of 95 on the 7-foot reflector. His drawing of 5 Nov. is in Tab. IX. vol. i. of the Selenotopographic Fragments. The small crater *v* in it corresponds *nearest* to the place of Linné, *y* (which is now still visible) not at all so, and still less the dark spot *g*.

Note.—In the Monthly Notices R. A. S., vol. xxvii. p. 298, Mr. Huggins has italicized the portion of Schroter's observation of the spot *v*. In Schmidt's reference I have italicized the word " nachsten " (nearest). Schmidt does not appear to have *identified v* with Linné (see *post*, p. 21).

2. LOHRMANN'S OBSERVATION.—1823, May 28, $2^h\ 12^m$ to $2^h\ 15^m$ Morgens, Wahre Dresdner Zeit (Topographie der Sichtbaren Mondoberflache, p. 92):—
" A ist die zweite Grube auf dieser Flache....neben einer von Sulpicius Gallus herkommenden Bergader, hat einen Durchmesser der etwas mehr als eine Meile beträgt, ist sehr tief, und kann in jeder Beleuchtung gesehen werden."

Translation.—A is the second crater upon this plain....near a ridge beginning at Sulpicius Gallus, it has a diameter of somewhat more than a mile, is very deep, and can be seen under every illumination.

LOHRMANN'S Note to his measure of A (Topographie der Sichtbaren Mondoberfläche, p. xv of Observations):—" Conon kann zur Zeit des Vollmondes nicht deutlich gesehen werden ; dagegen zeigt sich A immer als heller Punkt im grauen Mare Serenitatis."

Translation.—Conon cannot be seen distinctly at the time of the full moon, whilst A shows itself always as a bright point in the grey Mare Serenitatis.

3. BEER AND MÄDLER'S MEASURES.—1831, Dec. 12 and 13. Extract from a letter of Professor Mädler in English, dated 1867, June 6.

" The crater Linné, situated in 27° 47′ 13″ N. lat., and 11° 32′ 28″ W. long., has a diameter of 1·4 geographical miles (6·4 English miles). In full moon the edge of it is not very sharply limited, but in oblique illumination it is very distinct, and I have measured it seven times with great facility. The light of the edge is noted permanently 6° ; the very small inner space has nearly, or full the same brightness till the moment when shadows begin."

4. SCHMIDT.—Über die gegenwärtige Veränderung des Monderaters " Linné." Sitzungsberichte der K. Akademie, Wien, Bd. lv. Feb. 1867.

In this letter to Herr Haidinger, Herr Schmidt assigns to Linné a diameter of 5700 toises, or 36449 English feet, with at least a depth of 170 toises, or 1087 English feet.

SCHMIDT'S EARLY OBSERVATIONS, which included nearly 1300 lunar drawings.

1840. "Auf einer Generalcharte des Mondes, von 12 Zoll Durchmesser die ich nach eigenen Beobachtungen wahrscheinlich Ende 1840 ausarbeitete, finde ich 'Linné' als Crater angegeben. Lohrmann's und Mädler's Werke wurden mir erst 1843 in Hamburg zugänglich."

Translation.—On a general chart of the moon, diameter 12 inches, which I constructed from my own observations probably about the end of 1840, I find Linné *marked as a crater.* The works of Lohrmann and Mädler were not accessible to me until the year 1843 at Hamburg.

"1841, April 27. Abends; zunehmende Phase im Ostrande des Mare Serenitatis. In Nr. 4 fehlt Linné, aber zwei kleine Crater im Nordwesten sind stark ausgezeichnet."

Translation.—1841, April 27, evening. The morning terminator on the eastern boundary of the Mare Serenitatis. In No. 4 Linné is wanting, but two small craters are strongly marked on the north-west.

"1841, Mai 28. Abends; Phase uber Eratosthenes und Plato. In Nr. 11 ist Linné nicht angegeben."

Translation.—May 28, evening. The terminator on Eratosthenes and Plato. In No. 11 Linné is not marked.

"1841, September 6. Abends; abnehmende Phase über Eudoxus und Menelaus (Nr. 36); Linné nicht gezeichnet."

Translation.—September 6, evening. Evening terminator on Eudoxus and Menelaus (No. 36); Linné not marked.

"1841, December 2. Morgens; abnehmende Phase über Atlas und Gutenberg. In Nr. 52 habe ich Linné in grossem Abstande von der Lichtgrenze als Crater gezeichnet."

Translation.—December 2, morning. Evening terminator on Atlas and Gutenberg. In No. 52 I have marked Linné *as a crater* at a great distance from the terminator.

"1841, December 2. Abends; abnehmende Phase über Isidorus und Fracastor. In Nr. 53 ist Linné verhaltlich sehr gross als Crater angegeben."

Translation.—December 2, evening. Evening Terminator on Isidorus and Fracastor. In No. 53 Linné is given proportionately very large *as a crater.*

"1841, December 3. Morgens; abnehmende Phase uber Posidonius und Piccolomini; Nr. 54 stellt den Linné deutlich als Crater dar."

Translation.—December 3, morning. Evening terminator on Posidonius and Piccolomini; No. 54 represents Linné distinctly *as a crater.*

"1842, Janner 3. Morgens; abnehmende Phase über Eudoxus und Menelaus. In Nr. 63 ist Linné, hart an der Phase, nicht verzeichnet."

Translation.—1842, Jan. 3, morning. Evening terminator on Eudoxus and Menelaus. In No. 63 Linné, close to the terminator, is not marked.

"1842, Februar 16 und 17 (Nr. 74 und 75); bei zunehmender Phase ward Linné, der Lichtgrenze nahe, nicht gesehen."

Translation.—Feb. 16 and 17. Morning terminator. Linné, which was near the light-boundary, was not seen.

"1842, Juli 14. Abends; zunehmende Phase im Ostrande des Mare Serenitatis. Beobachtet ward zu Hamburg an einem guten Fernrohre von *Banks.* Unter 88-maliger Vergrösserung ward Linné als sehr kleiner Crater gezeichnet."

Translation.—July 14, evening. Morning terminator on the eastern

border of the Mare Serenitatis. . Observed Linné at Hamburg with a good telescope by Banks. With power 88, it was represented as a very small crater.

"1843, Mai 9. Abends; zunehmende Phase schon über den Copernicus hinaus. Bei vorzüglich guter Luft zählte ich am zuletzt-genannten Fernrohre 22 Crater im Mare Serenitatis, darunter in Nr. 270 sicher den Linné."

Translation.—May 9, evening. Morning terminator already passed over Copernicus. The air being particularly favourable, I counted with the last-mentioned telescope 22 craters in the Mare Serenitatis, and amongst them in No. 270 is certainly included Linné.

"1843, August 17, um 13 Uhr; am grossen Fernrohre der Hamburger Sternwarte beobachtet bei guter Luft. Beide Bergadern von Sulpicius Gallus nach Norden ziehend, an der abnehmenden Phase, gut sichtbar, aber vom Linné keine Spur (Nr. 326)."

Translation.—August 17, about 13 hours; observed in good atmosphere with the great telescope of the Hamburg Observatory. The two mountain veins running northerly from Sulpicius Gallus were well visible on the evening terminator, but of Linné no trace.

Recent Observations—Results.

1°. An ill-defined white spot, not unlike a cloud, greater in extent than the crater of Lohrmann, Beer and Mädler, and Schmidt.

2°. A large shallow crater that has been very rarely seen.

3°. A small crater *within the shallow crater*, first seen as a crater by Father Secchi on Feb. 11, 1867.

These appearances of Linné have not been recorded previously as *co-existing* *.

Observations of the White Spot.

These have been very numerous. No doubt whatever has been cast on this appearance of Linné since Oct. 15, 1866. The only question that exists has reference to the variability or invariability of its size, and probably of its reflective power.

Schmidt's Recent Observations. *Note.*—It will be sufficient to quote merely the dates of these observations except the first, in which Schmidt speaks of his missing for the first time the crater-form of Linné.

"1866, October 16. Abends; zunehmende Phase über den Caucasus. Luft sehr still, schwach dunstig. Viele kleine Crater im Mare Serenitatis sichtbar; Linné aber, obgleich höchst günstig beleuchtet, erschien nicht als Crater, sondern als kleine Wolke, ähnlich dem weissen Flecken östlich bei Posidonius in der grossen Bergader, welcher Fleck (in Wirklichkeit ein grauer höherer Gipfel jener Bergader) in Lohrmann's Sect. III. mit 16 bezeichnet ist, bei Mädler aber γ heisst. Zum Ersten Male vermisste ich den Linné, oder vielmehr seine Craterform, die sich jetzt tief beschattet, und in besonderer Deutlichkeit hätte zeigen müssen."

Translation.—1866, October 16, evening. Morning terminator over Caucasus. Air very still, slightly misty. Many small craters visible in the Mare Serenitatis; but Linné, although most favourably illuminated, did not appear as a crater, but as a small cloud similar to the white spot eastward near Posidonius in the great mountain-ridge, which spot (in reality a grey highish

* 1867, Nov. 3. Mr. Prince, of Uckfield, saw the shallow crater and the small crater at the same time: see *post*, p. 13.

peak of that mountain-ridge) is denoted by 16 in Lohrmann's Sect. III., but is called γ by MÄDLER. For the first time did I miss Linné, or rather its crater-form, which at that time ought to have shown with especial distinctness and deeply shadowed.

Schmidt observed Linné as a spot of light *only*, more or less similar to γ Posidonius, on the undermentioned days: 1866, Oct. 18; Nov. 14, 17, 19, 22, 23, 24, and 25. On Nov. 26 he recorded "no trace of Linné." He also observed it as a light-spot on Dec. 14–16 (and following evenings), 25, and 27. On Dec. 27 he speaks of it as "inconsiderable." 1867, Jan. 13, 14 to 19, and 24, he still observed it as a light-spot or small white cloud. Also on May 23, he estimated it at 0·6 of Sulpicius Gallus; May 24, estimated at 0·25 of S. Gallus; June 22, 0·33 of S. Gallus; and July 9, as the usual spot of light.

M. FLAMMARION observed the white spot on May 10, 1867, and described it as under (Comptes Rendus, tom. lxiv. 20 Mai, 1867, No. 20, p. 1020.) He does not appear to have seen either the large shallow crater, or the small crater or hill which were observed on the same day by Respighi and Schmidt.

"Une observation attentif montre immediatement que Linné *n'est plus un cratère*. Aucune ombre extérieure à l'est, aucune ombre au centre. En sa place il n'y a plus maintenant qu'une nuée blanche circulaire, ou plutôt une tache blanche attenant au sol, laquelle, loin de s'élever comme un cratère sur le fond un peu verdâtre de la mer de la Sérénité paraît n'être ni en relief ni en creux et ressemble à un *lac* plus claire que la plaine avoisinante."

Translation.—An attentive observation shows immediately that Linné *is no longer a crater*. No exterior shadow to the east, no shadow at the centre. In its place there is now nothing more than a white circular cloud, or rather a white spot contiguous to the ground, which, so far from elevating itself as a crater on the slightly greenish ground of the Mare Serenitatis, appears neither to be in relief nor as a depression, but resembles a *lake* brighter than the neighbouring plain.

1867, July 9. Mr. HUGGINS measured the length and breadth of the white spot, viz. 7″·854 length, and 6″·138 breadth. On the same evening I measured the white spot in the direction of position angle 0°, and found the diameter in this direction 7″·004; the mean of the length and breadth gives 6″·996 for an intermediate diameter.

1867, August, $6^d\ 8^h$. Distance of meridian of Linné from meridian crossed by terminator at the moon's equator 0° 6′·4, Linné being unenlightened. Later, when the moon was low in the west, Mr. BUCKINGHAM saw an *oval* spot rise gradually out of the dark part of the moon, which projected a shadow to the edge.

From the sketch accompanying the note, it would appear that this spot was somewhat *elevated* above the general surface, as the shadow extended to the terminator, also the cone of the little crater is shown casting an exterior shadow, the orifice being a black spot. On the same evening, at $8^h\ 30^m$, Mr. Bird noticed *two* notches on the terminator near the neighbourhood of Linné.

1867, Oct. 5. Mr. SLACK, of Camden Square (telescope 6½-inch aperture, silvered glass reflector), observed the white spot. He says, "The next night (Oct. 5) I thought the white patch round Linné smaller than on many former occasions, but changes of this sort are very common."

Mr. WEBSTER, of Dundee (telescope 7-inch aperture, achromatic object glass by Cooke), records, "Oct. 5, I could see Linné only as a small faint nebulosity."

1867, Oct. 10. Mr. SLACK. "The white spot Linné did not *melt* off *gra-*

dually into the colour of the surrounding sea as in some previous months. It showed as a distinct clear white spot, round which the sea was distinctly of a deeper tint—one of the nondescript ochreous *browns*. No symptoms of a cloudy edge was visible with my $6\frac{1}{2}$ and power 100."

In contrast with this and as illustrative of Mr. Slack's opinion of variations in the appearance of Linné (*see post*, p. 22) I quote the following passage from my note-book under date 1867, July 8:—

"The portion near the south border of the Mare Serenitatis was greatly in contrast with Linné and its neighbourhood. While the most minute furrow or cleft *could have been seen* near Sulpicius Gallus, Linné was so *indistinct* that nothing was visible except the spot of light, and this was quite undefined, so that any well-marked margin was *invisible*. Linné appeared as a light spot, *brighter* towards the centre."

On Oct. 17, to 15^h, G. M. T., Mr. F. Bird, of Birmingham, observed the white spot but could not see the small crater, nor any trace whatever of shadow, but he noticed that the place occupied by the small crater in July was in October *unusually bright*. It is to be remarked that the state of the air was almost as *bad* as possible at the time, so that it is doubtful if the small crater was really replaced by the small bright spot.

1867, Oct. 18, 16^h to $20^h\,30^m$. Mr. Buckingham observed the white spot to be *convex*.

Mr. Crossley on the same day saw the white spot as an irregular badly-defined patch, especially towards Bessel, on which side near the centre was the only shadow visible, which might have been the shadow of the supposed central peak from its position.

Analogous Spots.

The spot which, so far as I am aware, exhibits the closest analogy to Linné in its present state is IV A^{α} 17, IV A^{ζ} 39: see Report, 1866, pp. 251, 262 and 276, where it is simply recorded as a bright spot. 1867, May 11, $8^h\,0^m$ to $8^h\,30^m$, I record:—IV A^{α} 17, IV A^{ζ} 39 is a shallow crater on the S.W. side of the ridge forming the N.E. boundary of Hipparchus. 1867, Oct. 7, Rev. W. O. Williams of Pwllheli recorded it as "very bright," but said nothing of a crater.

On Oct. 17, 13^h to 15^h, G. M. T., Mr. Williams noticed it as a very conspicuous crater, and on Oct. 18, 17^h to 19^h, G. M. T., it was also very conspicuous with a central cone casting a shadow. In preparing area IV A^{β} for engraving, I have met with a spot still more analogous to Linné. It is west of Horrox, is marked IV A^{β} 37, and will be fully described in the letter-press of IV A^{β}.

Estimations and measures of the White Spot.

Table I. contains estimations and measures of the extent of the white spot in seconds of arc, English feet, and French metres. Those marked (*) are measures, all at an angle of position $=0°$, except the measures by Mr. Huggins marked respectively (†) the length, and (‡) the breadth of the white spot. The angles of position of these measures are not given. As the same angle of position gives a different line of measurement on the moon's surface from day to day, the measures are not referable to the same line across the white spot.

The number of English feet subtending an angle of $1''\cdot0$ at the centre of the moon's disk at mean distance is 6116·7. At any given distance from the centre this quantity is increased in the proportion of the secant of the angle,

measuring the distance from the centre, which in the case of Linné is equal to 29° 54′ 40″, therefore 6116·7 × secant 29° 54′ 40″ = 7056·6 English feet, which subtend an angle of 1″·0 at the mean position of Linné; but as this mean position may be either at perigee or apogee, where the value of 1″·0 may be greater or less, the above is the value at mean distance, which is never contemporaneous with mean libration. See Report, 1866, p. 245.

The apparent sizes of objects on the moon's disk are affected both by *distance* and libration. The former presents them alternately to the eye under larger and smaller angles, according as the moon is nearer to or further from us. The latter alters their positions on the disk, sometimes bringing them nearer to the apparent centre, at others removing them to a greater distance from it. Approximately, distance may affect the measurements of objects to an extent of about a 9th part of the *greatest* measures at the epoch of mean libration; for as mean libration may occur when the moon is in perigee, a measure taken at the time of apogee, when the moon is in a state of mean libration, will be less by about the 9th part of a measure taken at perigee mean libration.

Libration affects the measures of objects by presenting them under larger or smaller angles, according as they are nearer to or further from the centre of the apparent disk; thus an object of 6116·7 English feet in diameter, occupying the centre of the disk at mean distance, would subtend an angle of 1″·0. At mean Libration, moon in Perigee, an object of the same extent would subtend an angle of 1″·059 ±; moon in Apogee 0″·941. In the first case a similar object at an angular distance of 19° 54′ 40″ would appear foreshortened in a *radial* direction, the longer axis at right angles to a radius measuring 1″·059, the shorter axis 0″·996; the shorter axis of an object of the same diameter at a distance of 29° 54′ 40″ on the same radius would measure only 0″·918; the difference, 0″·078, is the change of angle arising from the displacement of such an object by libration (about the epoch of Perigee) equal to an arc on a radius of the moon's apparent surface of 10°, *i. e.* between 20° and 30°; on the opposite side of the orbit it is less.

Table I.

Estimations and measures of the extent of the white spot on the Crater Linné reduced to 29° 54′ 40″ = angular distance from the moon's centre.

Authority.	Epoch.	Date.	Seconds.	Eng. feet.	Fr. metres.
Schmidt..........	1866·794	1866, Oct. 18	″ 6 90	48688	14840
Birt	1866·953	1866, Dec 15	11 61*	81932	24972
Birt	1866·961	1866, „ 18	7 07*	49871	15201
Birt	1866 964	1866, „ 19	7 32*	51652	15744
Birt	1866·969	1866, „ 21	6 75*	47644	14522
Schmidt..	1866·986	1866, „ 27	1 81	12789	3898
Birt	1867·036	1867, Jan. 14	7 95*	56105	17100
Buckingham	1867·197	1867, Mar. 14	6 00*	42340	12905
Wolf	1867·443	1867, June 12	4·50	31755	9679
Birt	1867 515	1867, July 8	5·33*	37626	11468
Huggins	1867·518	1867, „ 9	7 85*	55423†	16893
Huggins	1867·518	1867, „ 9	6·14*	43314‡	13202
Birt	1867·518	1867, „ 9	7·00*	49426	15065
Birt	1867·520	1867, „ 10	5·36*	37848	11536
Birt	1867·528	1867, „ 13	6 31*	44528	13572

Brightness of the Whitish Spot.

Since Schmidt suspected a change in Linné he has recorded nine comparisons of the brightness of Linné with that of the spot on the S.E. of Posidonius marked γ by B. & M. (see *ante*, p. 6). On seven occasions he found it less bright than γ, viz. on 1866, Nov. 17, 19, 22, 23, and 24; and 1867, Jan. 13 and 14§. On Dec. 16, 1866, he recorded it equal to γ; and on Dec. 14, 1866, brighter than γ. I also found it less bright than γ on seven evenings, viz. 1866, Dec. 19, 1867, Jan. 14§, 15, Feb. 11, May 11 and 15, and Aug. 12. On May 17 and July 13 I recorded it as equal to γ, and brighter than γ on March 14 and Aug. 10; on March 14 Mr. Buckingham estimated it as equal to γ. The above are comparisons with γ only, they give no information as to the degree of brightness with which Linné reflected the sun's light. The following are my estimations of the brightness of Linné, the scale being shadow=0°, the bright mountain in Aristarchus=10°.

1866, Dec. 14.	3°·0	1867, Jan. 12.	3°·0	1867, July 10.	4°·5
„ 15.	3·5	„ 14.	4·0	„ 13.	5·0
„ 18.	5·5	„ 15.	5·0	Aug. 10.	4·0
„ 19.	5·0	July 8.	3·0	„ 12.	6·0
„ 21.	4·0	„ 9.	4·0		

These numbers appear to indicate that between 1866, Dec. 14, and 1867, Aug. 12, Linné increased in brightness as the altitude of the sun increased.

The following are estimations of the brightness of γ Posidonius contemporaneous with those of Linné.

1866, Dec. 19.	5°·1	1867, July 8.	5°·0	1867, July 13.	5°·0
„ 21.	4·5	„ 9.	5·0	Aug. 10.	3·9
1867, Jan. 15.	5·5	„ 10.	5·0	„ 12.	6·2

Observations were made on the evenings of Dec. 18 and 19, 1866, with the view of confirming the estimations by comparison with other objects. They were as follows:—

	Dec. 18.	Dec 19.
Proclus	9°·0	9°·0
Censorinus	8·5	9·0
Dionysius	8·0	8·5
Conon	7·0	7·0
Linné	5·5	5·0
γ Posidonius....		5·1
Bessel	4·0 (ring)	4·5

The similarity of appearance under high illumination exhibited by Linné and γ Posidonius [I $E^{6\ 3}$] is remarkable, especially as the two objects are so very dissimilar in character. The white spot on the site of Linné, so far as we know at present, differs, as we see it, very little, if any, in level from the surrounding surface of the *Mare Serenitatis*. Most of the former records place Linné on or very near a ridge crossing the *Mare Serenitatis*. Since October 16, 1866, the appearance of this ridge *in the immediate neighbourhood of Linné has* NOT *been recorded*. On July 8, 1867, I have this note:—"The ridge between Linné and Sulpicius Gallus quite perceptible, *except a small portion near Linné*." This ridge is of variable height, the shadows distinct,

§ Indicates that Schmidt's observation was contemporaneous with mine.—W. R. B.

especially of the highest part, a little south of Linné. I $E^{\epsilon 3}$ [γ Posidonius], when near the morning or evening terminator, shows itself as a distinct mountain peak of 150 toises, or 959·2 English feet in height. It is only when the sun attains a considerable altitude on γ that it presents the same appearance as Linné, viz. that of a white diffused cloudy patch. So far as I am aware, it is only *recently* that this similarity of appearance between these objects has been observed. Although many *mountains and craters* lose their distinguishing features, and appear as round white spots when the sun is at a great altitude above their respective horizons, there are numerous craters that present the characteristic appearance of having a *dark interior*, surrounded by a *bright ring* under the more direct rays of the sun, when most mountains are seen as bright spots.

Connected with the similarity of appearance under high illumination is another interesting feature characterizing Linné and γ Posidonius [I $E^{\epsilon 3}$], viz. the existence during the period of observation, of crater-openings on both. Of that on Linné I $E^{\gamma 2}$ we have numerous records. That on γ [I $E^{\epsilon 5}$] is certainly smaller than I $E^{\gamma 2}$, and has been seen only on five occasions. It was discovered 1867, January 14, by Mr. Knott, with his 7⅓-inch O. G. by Alvan Clark. His own words will best describe the nature of the discovery. Writing under date of March 3, 1867, he says, "While observing Linné on the 14th of January, at about $10^h\ 30^m$ G. M. T., I had myself a strong impression of a *dark spot*, as described by Schmidt, but definition was so poor, and I saw, or fancied I saw, traces of a similar appearance on Posidonius γ, that I regarded it as an *illusion*, and made no note of it at the time. I could not, however, free my mind from the idea that there *might be something in it*, and accordingly, two days afterwards, I added the following note, which I transcribe *verbatim*:—

"I had a *very strong impression*, with various eyepieces, of a small central dark spot on the diffused patch covering (?) Linné, so strong that I inclined to regard it as having a real existence; as, however, I saw a similar appearance, *though not nearly so strongly marked*, on γ [Posidonius], I can only regard it as a curious optical illusion."—Note added January 16, 1867.

This dark spot on γ Posidonius was next seen by Mr. Buckingham on the 11th of April, 1867. His observation is thus recorded:—

"1867, April 11, 6^h to $10^h\ 59^m$. Air very steady, but slightly hazy, and found γ Posidonius a fine crater, $0''{\cdot}5$, seen well with 360 and higher, clearly with 250, but could not with 120."

1867, May 11. Herr Schmidt recorded as follows:—"I also see a delicate black point in γ Posidonius".

1867, Oct. 16. Mr. Buckingham saw and described it as very black.

1867, Dec. 4, $7^h\ 30^m$, G. M. T. Mr. Knott records that it was well seen*.

The increase of the brightness of Linné as the sun attains a greater altitude above its horizon, especially as γ Posidonius does not exhibit it in so marked a degree, may bear a passing remark without at all hazarding an

* About the middle of January 1866, Mr. Leigh, then of Birkenhead, now of Warrington, detected a curious group of three small craters and three small mountains north of Aristoteles, which is figured by Webb in the 'Intellectual Observer,' No. 60. vol. x. Jan. 1867, p. 441. April 11, 1867, Webb detected on the western of the three mountains a shallow pit (I $I^{\iota 7}$) (see 'Intellectual Observer,' No. 64. vol. xi. May 1867, p. 282). Webb had previously (1866, April 21) detected a cavity or pit (I $I^{\delta 4}$) on the western mountain of B. & M.'s Γ north of Aristoteles, which was extremely plain on April 11, 1867. In connexion with the phenomena presented by Linné, the value of observations of these and similar objects is obvious.

opinion as to change. Varying angles of illumination appear to affect objects on the moon's surface *differently*; for example, under an oblique illumination, when the sun shines more directly on the steep sloping sides of some craters, they appear very bright; this brightness arises from *two* circumstances, viz. the nature of the surface of the sloping sides, and the angle of illumination upon them being more direct; this of itself will make a difference in the brightness (when no real difference exists in the reflective power of the interior and exterior surfaces) at the times of sun-rising and setting; as the sun rises higher above the horizon the brilliancy from this cause declines. The variations in the brilliancy of Linné, γ Posidonius, and other spots which are similarly affected, do not appear to be produced in the same manner. The difference arising from elevation in the case of Linné (if it exists) seems to be too slight to occasion any appreciable effect. The gradual brightening of such spots as Linné, especially when situated on a ground which *darkens* under the more direct rays of the sun, appears to point to something in the nature of the surface of the spot—as contrasted with that of the surrounding surface—on which the sun's rays exert an influence, rendering it, for the time being, capable of reflecting a greater amount of light. While there is a more or less constant relation between reflective power and angle of illumination, the recorded *differences* of reflective power under the *same* angles of illumination, would indicate that these differences depend upon other circumstances than increase and decrease of illuminating angle. The phenomena presented by Linné during the last twelve months are strikingly in contrast with those presented by Plato, as observed by me between 1859 and 1863. Linné is faint under oblique rays, bright under those that are more direct. Plato reflects more light under oblique, and less under more direct rays, *i. e.* the surface is of a *darker* tint under a higher angle of illumination.

The Shallow Crater.

This object, of which no measures exist, has not been previously recorded, unless Schröter's description of the spot *v* refers to it (see *ante*, pp. 3 & 4). His language is, however, rather ambiguous, and it is doubtful as to whether he describes a plain on the same level as the adjacent surface of the *Mare Serenitatis*, or one bounded by a low wall which did not rise above the surrounding level. It appears that he did not determine the precise nature of the spot *v*. Schroter's description is quite irreconcileable with the appearance of Linné as given by Lohrmann and by Beer and Mädler.

Observations of the Shallow Crater.—These have been but few, as under:—

1. 1867, Jan. 12. Mr. Knott, 7⅓ Alvan Clark, Dawes's eyepiece, powers 145 and 240, saw the "Ghost" of the ring of Linné. His observation is recorded as follows, January 12, 6^h 40^m to 7^h 15^m, G. M. T.:—

"I saw clearly the '*Ghost*' of the ring of Linné. * * * It is broader (and brighter?) on the western side. The shading in the interior is of about equal intensity with that of the surrounding *Mare*. I do not see any real interior or exterior shadow, though the shadows in neighbouring craters, even those of very small dimensions, are very distinct. The ring or wall of the crater has a slightly nebulous appearance, and is in brightness barely equal to that of the knoll on the *Mare* east of Posidonius, marked γ on B. & M.'s large map. Its diameter is, to my eye, less than that of Sulpicius Gallus."—Astronomical Register, No. 50, Feb. 1867, p. 33.

2. Jan. 12. Mr. Buckingham saw, in moments of quiet air and good definition, "a very shallow depression all over the enlightened spot of Linné,

except on the south-west, where an *elevation* could be seen brighter than other parts" *.

3. Jan. 12, 5.15 P.M. The Rev. HENRY COOPER KEY examined Linné with his silvered glass reflector of 12 inches aperture. He says "the air was very tremulous (the temperature had fallen to 22°); but still definition was fairly sharp with powers of 250 and 300. At first the appearance was certainly that of a whitish cloud obscuring the crater; but upon long gazing and using averted vision, I could plainly make out a centre or nucleus, and presently afterwards a marginal ring of perhaps twice the diameter of the original Linné."—Astronomical Register, No. 50, Feb. 1867, p. 33.

4. Feb. 14. Mr. GROVER, with a 2-foot Gregorian Reflector, 4-in. aperture, powers 50 to 75, saw the ring of Linné faint, plainest on the preceding side, very obscure on the following. His observation is thus recorded:—

"I saw the ring of Linné with certainty, though but faint; it was much the plainest on the preceding side, and I was tolerably certain of an interior shadow; be this as it may, the interior floor was certainly seen, and very dusky, * * the following side of the object is very obscure."

5. April 11. Rev. T. W. WEBB saw the ring faintly. He says, "With close attention I once or twice thought I saw the 'Ghost,' described by Mr. Knott as a pale ring, about as large perhaps as that figured by B. and M., a little brighter than the included or exterior surface."—Intellectual Observer, No. 64, May 1867, p. 282.

6. May 10. M. RESPIGHI.—Les Mondes, 13 Juin 1867. "Dans certains moments où l'air était parfaitement tranquille, le contour de la tache blanche paraissait formè par le couronnement d'un grand cratère à petite profondeur. Le bord de la tache paraissait mieux défini du coté oriental que dans les autres parties, et avec quelque trace d'ombre."

Translation.—In certain moments, when the air was perfectly tranquil, the contour of the white spot appeared formed by the crown of a large crater of little depth. The border of the spot appeared better defined on the eastern side than on the other parts, with some trace of a shadow.

7. July 8. Mr. HUGGINS. "On the evening of July 8, when a great part of the light reflected from our atmosphere was removed by means of a Nicol's prism placed next the eye, I observed a shadow within the western margin of the shallow crater."—Monthly Notices, vol. xxvii. p. 296.

8. Oct. 18, $16^h\ 30^m$. Mr. BUCKINGHAM saw several small projecting points of the old ring, and describes the ring-summit of the white spot as *very white*.

9. Nov. 3, $5^h\ 5^m$. L.M.T. Maresfield, Sussex. Capt. NOBLE saw the shallow crater *complete*. The following is an extract from his note-book:—

"For the first time I see Linné unmistakeably as a crater, with an undoubted depression in the interior of the ring. The bottom of the crater is very light, in fact practically identical in tint with the surrounding Mare; but Linnæus is a *ring* surely enough * * * It has a good deal of the effect of the annular nebula (57 M) in Lyra. The S.W. part of the ring is the thickest portion of it. I first detected these appearances with a power of 154, and subsequently used one of 255; but this only rendered them more indubitable. Nothing resembling the dark spot seen by Mr. Huggins on the 11th of last May (Monthly Notices, vol. xxvii. p. 296) could be detected."

10. Nov. 3, $5^h\ 30^m$. Mr. C. L. PRINCE, of Uckfield, saw the large shallow crater of Linné *well defined*, and the smaller crater as a black point. The observation is thus recorded:—

* See *ante*, p. 8, 1867, Oct. 18, when Mr. Buckingham saw the white spot *convex*.

"Nov. 3. Upon looking at the moon this evening I saw Linné as a well-defined crater, with little of that cloudy haziness which has lately supervened it; also by glimpses I saw a dark line (as if a shadow) on the side next the sun, and within the crater. Saw also the smaller crater as a black point."

Mr. Prince adds, "On the following evening the cloudy spot had completely obscured the crater again. I could not detect any crater"*.

11. 1867, Dec. 3, $5^h\ 0^m$. Messrs. JOYNSON and WILLIAMS, of Liverpool, saw the shallow crater. The record of the observation is as follows:—"The 'shallow' oval crater was quite distinct, and south preceding there appeared to be the commencement of another (see *ante*, p. 7, Aug. 6, 8^h). The thin black line of shadow was well defined; but the impression given was that the hill is either very low and rounded, or, if not low, that the sides are of a very gradual ascent. The 'small' crater could not be seen."

THE SMALL CRATER.

There is no record whatever of this object as a crater until 1867, Feb. 11. As a *white hill* or *black point* it appears to have been noticed about two months earlier. From the time when Herr Schmidt suspected that a change had taken place in Linné until December 13, 1866, nothing was seen but the large white spot. On this day Schmidt discovered a delicate shadow-projecting hill. The next evening, December 14, Mr. Buckingham saw a shadow, or very black point. Dec. 26, and 1867, Jan. 25, Schmidt again saw these objects; and on Feb. 11, 1867, Secchi found a small crater. During March, April, May, June, and July, this small crater was seen by several observers, and estimates of its diameter given. On July 9 its diameter was measured by Mr. Huggins. The following are the most important observations of this object:—

"1866, Dec. 13. [Herr SCHMIDT.] Abends. Luft mitunter recht gut. Die zunehmende Phase hatte soeben den Linné überschritten. An seiner Stelle war Anfangs nicht der geringste Gegenstand zu entdecken, obgleich die dortigen feinen, 10–30 Toisen hohen Adern sich eben so deutlich darstellten, als die kleinen Crater im Nordwesten. Unter Anwendung einer 300-maligen Vergrösserung bemerkte ich am Orte des Linné, der sich *nicht* durch helleres Licht auszeichnete, einen äusserst feinen schattenwerfenden Hügel, für den eine sorgfältige Schätzung 300 Toisen Durchmesser, und 5–6 Toisen Höhe ergab. Gegen 6 Uhr betrug die Sonnenhöhe für den Horizont des Linné $1\frac{1}{2}$ Grad. Weder innerer noch äusserer Schatten war sichtbar; das ganze Cratergebirge fehlte durchaus, und ich sah nur glatte graue Ebene."

Translation.—Dec. 13, evening. Air at times very good. The morning terminator had just passed over Linné. At first there was not the smallest object to be discovered in its place, although the delicate ridges about, of from 10–30 toises in height (between 60 and 200 English feet), were clearly visible, as well as the small craters in the N.W. By applying a power of 300, I remarked in the place of Linné, which did not show itself distinctly through the brighter light, an extremely delicate shadow-projecting hill, for which a careful estimation gave a diameter of 300 toises (about 1918 English feet), and a height of 5–6 toises (between 30 and 40 English feet). Towards 6 o'clock, the sun's altitude for the horizon of Linné amounted to $1^\circ{\cdot}5$. Neither interior nor exterior shadow was visible; the whole crater-mountain was entirely wanting, and I saw only a smooth grey plain.

1866, Dec. 14. Mr. BUCKINGHAM. 6^h to 7^h, equatoreal 9 inches aperture, power 240 and 361. Mr. Macgull of Glasgow present. "Air unsteady, but

* 1867, Nov. 3, $8^h\ 30^m$. Mr. Lockyer found Linné very difficult to see. It was only a white patch.—Astronomical Register, No. 60, Dec. 1867, p. 254.

occasionally could see a shadow very black near the centre of Linné. Either in the crater, or it might be the shadow of a very small peak, very white. Several times distinctly seen on the W. part of the centre of Linné (not at the edge), but no appearance of usual crater or shadow; the shadow seen was a black but not round spot, but longer N. and S."

"1866, Dec. 26. [Herr SCHMIDT.] Von 12–16 Uhr. Vorzüglich klare, ganz stille Luft, so dass ich die stärksten Oculare anwenden konnte. Die Phase berührte den Westrand des Mare Serenitatis; da γ Posidonius, der Phase nahe, Schatten warf, und also nicht mehr als Lichtfleck erschien, konnte er nicht mehr mit Linné verglichen werden. Im Mare zählte ich über 100 Crater, darunter nordwestlich von Linné deren sieben fast in einer Reihe, die schon Schröter am 27 füssigen Reflector bemerkt hatte. Aber auch jetzt war Linné ein gewöhnlicher Lichtfleck von geringer Augenfalligkeit. Von $14\frac{1}{2}$–16 Uhr sah ich in ihm mit 500–600-maligen Vergrösserung, einen äusserst feinen schwarzen Punkt, den ich $=\left(\frac{x}{6\cdot 5}\right)$ schätzte, aber $x=\left(\frac{\text{Bessel}}{6\cdot 5}\right)$, was auf einen wahren Durchmesser von 265 Toisen führt. Entweder war es der Schatten eines sehr kleinen Hugels, oder der Rest des ehemals 5700 Toisen breiten Craters. Die Höhe der Sonne fur diese Gegend war jetzt $=15°\cdot 9$."

Translation.—Dec. 26. From 12^h to 16^h particularly clear and perfectly still atmosphere, so that I could use the most powerful eyepieces. The terminator was in contact with the western edge of the *Mare Serenitatis*. As γ Posidonius, being near the terminator, threw a shadow, it could no longer be compared with Linné. In the Mare I counted more than 100 craters, several N.W. of Linné, seven of them almost in a row, which Schröter had already noticed with the 27-feet reflector. But even now Linné was an ordinary spot of light, but little conspicuous. From $14^h\ 30^m$ to $16^h\ 0^m$ I saw in it with a power of 500–600 an extremely delicate black point, which I estimated as equal to $\left(\frac{x}{6\cdot 5}\right)$, but $x=\left(\frac{\text{Bessel}}{6\cdot 5}\right)$*, which indicates a real diameter of 265 toises (1695 English feet). It was either the shadow of a very small hill, or the remainder of the crater, 5700 toises (36,449 English feet) wide. The height of the sun at this region was 15° 9′.

* As illustrative of Herr Schmidt's estimations of heights the reader is referred to B. and M.'s method, as described in 'Der Mond,' § 65, p. 98, a translation of which, by W. T. Lynn, Esq., is as follows:—"To measure and calculate the heights of all the mountains in the moon which, under favourable circumstances, throw perceptible shadows, would not only be inconceivably tedious and troublesome, but, besides this, the desired degree of accuracy would still, in the majority of cases, not be attained, because the shadows are too short. But when an observer has acquired sufficient practice by repeated measurements under different angles of illumination, he may use one measured mountain (selecting one as high as possible) as a standard of estimation for others lying in its neighbourhood, especially when they are nearly the same distance from the terminator. Possessed of some practice in eye-estimations, he will easily be able to find how many times the length of a small shadow is contained in the greater one formed by the principal mountain. Thus it was estimated on the 17th of March, 1834, that the shadow of the N.W. wall of Egede was equal to $\frac{1}{15}$ of the shadow of the wall of Eudoxus, the height of which latter was determined by calculation to be 1627 toises. Egede is situated in the neighbourhood of Eudoxus, and its distance from the terminator was then $\frac{1}{2}$ that of Eudoxus, so that approximately the height of its N.W. wall was $\frac{1}{15}\times\frac{1}{2}\times 1627=54$ toises above the interior surface. In this, or a similar manner, have many of the elevations given in the topographical description been determined; those actually calculated according to the above formulæ are set down in § 67 following."

Herr Schmidt, speaking of this method in a letter to Mr. Lynn, says, "Such estimations are very accurate, and between hills of the height of 50-200 toises which have been measured, differences of elevation of 5 or 6 toises can, when close to the terminator, be satisfactorily and certainly estimated."

"1866, Dec. 27. [HERR SCHMIDT.] Von 13 bis 19 Uhr. Luft sehr still, aber nur zeitweilig ganz dunstfrei. Anfangs zog die Lichtgrenze über Bessel, zuletzt war am Linné die Sonnenhöhe nur noch 3°. Keine Spur eines Craters erschien, kein Schatten, weder innen noch aussen an dem unbedeutenden, matten Lichtfleck dessen jetzt sehr verringerter Durchmesser nur etwa noch 2000 Toisen halten mochte. Der gestern in ihm sichtbare sehr kleine schwarze Punkt fehlte heute. Es war also nicht der Schatten eines Hügels, der heute viel grösser hätte erscheinen müssen."

Translation.—Dec. 27. from 13^h to 19^h. Air very still, but only occasionally quite free from mist. At first the terminator passed over Bessel, afterwards the sun's height at Linné was at the most 3°. There appeared no trace of a crater, no shadow, either within or without the inconsiderable faint spot of light, of which the now much diminished diameter might measure only about 2000 toises (12,789 Eng. feet). The very small black point visible in it yesterday was wanting to-day. It was therefore not the shadow of a hill, which would have appeared much greater to-day.

1867, Jan. 12. Mr. BUCKINGHAM saw an *elevation* on the S.W., in the shallow crater, brighter than other parts. See *ante*, pp. 12, 13.

"1867. Jan. 25. [HERR SCHMIDT.] $13^h{\cdot}5$–$16^h{\cdot}5$. Luft besonders gut. Sonnenhöhe nur noch 12°–13°. Linné ein matter Lichtfleck. Aber an 500-maliger Vergrösserung zeigt sich mitten ein ausserst feiner schwarzer Punkt, und ostlich daneben eine sehr feine, weisse Kuppe. Beide im Durchmesser respective 200 und 300 Toisen. Keine Spur eines Craters, wie solche in scharfen Formen überall im Mare zu sehen sind. Auch der westliche matte Fächer am Linné noch kenntlich."

Translation.—Jan. 25, $13^h\ 30^m$–$16^h\ 30^m$. Air particularly good. Sun's height still only 12°–13°. Linné a faint spot of light, but with a power of 500 there appeared within an extremely delicate black point, and east of that, close to it, a very fine white summit. The respective diameters of the two 200 and 300 toises (1279 and 1918 Eng. feet). No trace of a crater, as such are to be seen generally in the Mare in sharp forms. The westerly faint fan of light in Linné is also still discernible.

During the interval between Jan. 25 and Aug. 20 Herr SCHMIDT appears to have seen the cone only, which he describes as a hill, and not the orifice which he had formerly seen and described as a fine black point.

"1867, Feb. 10. Ganz unruhige Luft am 9^u. Linné *in der Lichtgrenze* erscheint als sehr feiner Hügel, viel kleiner als die Nachbar-Crater gegen N.W."

Translation.—1867, Feb. 10. The air very much disturbed. About 9 o'clock Linné, *on the terminator*, appeared as a very delicate hill, much smaller than the neighbouring craters towards the N.W.

"1867, Feb. 11. Sonne Hohe für Linné=12°. Keine Spur eines Craters; eine gewöhnliche matte Wolke, darin ein sehr feiner Hügel, noch mit Schatten."

Translation.—1867, Feb. 11. Sun's altitude at Linné=12°. No trace of a crater; an ordinary faint cloud, in which is a very delicate hill, still having a shadow.

Herr SCHMIDT adds this note:—"Von dieser Art sind *alle* hiesigen spätern Beobachtungen. Wenn Andere jetzt noch behaupten dass sie am Orte des Linné einen *Crater* sehen, so zeigt es mir dass sie den Ort des Linné überhaupt ganz verhehlt haben, oder falls sie einen *sehr feinen* Crater am Orte des Linné sehen, dieser Umstand meine Beweisfuhrung nur bestätigen kann. Linné war früher ein bedeutender Crater, der dritt-grosster im Mare, nach Bessel und Gallus."

Translation.—Of this kind are all the more recent observations at this place. If other persons now still assert that they see a *crater* in the place of Linné, this only proves to me that they have quite missed its place; or, in case they do see a *very delicate* crater in the place of Linné, this circumstance can only confirm the fact brought forward by me. Linné was formerly a considerable crater, the third in magnitude in the Mare, next after Bessel and Gallus.

"1867, Feb. 11. [PADRE SECCHI.] Le 11, au soir, Linné était déjà assez avancé dans la lumière et à 7 heures on voyait nettement un très petit cratère environné d'une éclatant auréole blanche qui brillait franchement sur le fond sombre du M. Serenitatis. Le grandeur de l'orifice du cratère était de $\frac{1}{3}$ de seconde au plus, et l'auréole était un peu plus large que *Sulpicius Gallus.*"—Comptes Rendus, tom. lxiv. 25 Fevrier, p. 345.

Translation.—On the 11th, in the evening, Linné had already advanced into the light, and at 7 o'clock a very small crater was distinctly seen, surrounded by a brilliant white aureole, which glittered against the dark ground of the *Mare Serenitatis.* The size of the orifice of the crater was at most $\frac{1}{3}$ of a second, and the aureole was a little larger than Sulpicius Gallus.

1867, March 14. Mr. BUCKINGHAM measured the "cloudy bright patch," and found it to be 6″ in diameter. He saw *into* the small crater, which he estimated to be equal to the largest on and near to the centre of Plato. He saw a slight shadow within the crater on the west side.

1867, March 15. Mr. DAWES, with power 160 on his 8-inch Cooke, saw "an *excessively minute black dot in the middle of Linné.*"

1867, March 15. Mr. BUCKINGHAM again saw the small crater *without* the shadow seen on March 14.

1867, April 10. RESPIGHI saw at sunrise on Linné, and precisely at its place, a brilliant spot or point entirely isolated on an obscure ground.

1867, April 11. The small crater on Linné was seen by Messrs.

RESPIGHI.

BUCKINGHAM, *west* of the centre, with the cone leading to it.

WEBB, who saw the ring of the shallow crater faintly, not at the same time that he saw the small crater, but only in a few doubtful glimpses.

HUGGINS, but only its bright west margin.

DAWES, who saw the dark spot and bright west edge. Mr. Dawes says, "On the west side there is a little curved edge which looked slightly raised like the edge of a crater."

April 12. Mr. CARPENTER, with the Great Equatoreal at the Royal Observatory, Greenwich, saw a crater which he has drawn as on the site of Linné, surrounded by the aureole as described by Secchi.

In the suitable and favourable evenings of April and May 1867, Professors D'ARREST AND SCHJELLERUP saw the crater opening in the middle of the large bright and somewhat diffused spot, and estimated the diameter of the circular shadow at not more than 0″·9, at the most 1″·1. Prof. Schjellerup adds, "I will just remark that the crater-opening is not nearly so striking as might be supposed from Mr. Huggins's drawing in the June Number of the Monthly Notices."

1867, May 10. SCHMIDT saw, in place of the small crater, an *enlightened mountain,* or bright shadow-projecting hill, half the size of the next neighbouring crater on the north-west (Linné A, B. & M.; I E *), of 0″·45

* B. and M. assign a brightness of 5° to this crater, and delineate it as *larger* than the northern of the three craters N.W. of Linné, which they do not notice in their text. A is now *smaller* than the northern crater, and on the evening of Dec. 7, 1867, it was scarcely

diameter, or 500 toises* (3200 Eng. feet), and 80–90 toises (between 500 and 600 Eng. feet) high (Les Mondes, 1st Août 1867, p. 566). Also, in a letter to W. T. Lynn, Esq.†, he says, "1867, Mai 10. Phase durch Calippus und Hadley. Für Linné stand also die Sonne erst wenige Grade hoch. Linné sehr verändert, an seinem Orte ein auffallend heller Schattenwerfender Hügel halb so gross als der erste nordwestlich benachbarte Crater. Es ist sicher eine neue Veränderung eingetreten."

Translation.—The terminator through Calippus and Hadley. On Linné the sun was therefore only a few degrees high. Linné was much altered; in its place a remarkable bright hill casting a shadow, half as large as the nearest crater on the north-west [I $E^{\gamma 3}$]. A new change has undoubtedly taken place.

1867, May 10. RESPIGHI saw the little crater on an obscure ground. In his *résumé* of his observations, Respighi assigns a diameter of 4″·0 to this crater and a great depth.

1867, May 10. Mr. INGALL, with a 4·5-inch Dialyte, power 200, saw the small crater "very faint, only as an 'aspect' or 'IDEA' of a small crater in the centre."

"1867, Mai 11. SCHMIDT. Linné als weisse Wolke: darin ein feiner weisser schatten-werfender Punkt, ohne der gestrige Hügel. Auch in γ Posidonius sehe ich einen feinen schwarzen Punkt."

Translation.—Linné like a white cloud: in it a delicate white point casting a shadow, without the hill noticed yesterday. I also see a delicate black point in γ Posidonius.

1867, May 11. The small crater was seen by Messrs.

KNOTT, with interior shadow intensely *black*.

HUGGINS, very sharply defined. In centre nearly, but rather nearer the west margin. Mr. Huggins adds, "The appearance suggested that the bright walls of the crater were a little elevated above the 'nebulous light.'"

Mr. Huggins's observations, with engraving of the white spot and crater-opening, will be found in the Monthly Notices of the Royal Astronomical Society, vol. xxvii. pp. 296 to 298.

"1867, Juni 9. [SCHMIDT] Linné eine unscheinbare Lichtwolke: in ihr, etwas westlich, ein feiner hellerer Hügel, fast schon ohne Schattenspur."

Translation.—Linné an insignificant light cloud: in it, somewhat westerly, a delicate brightish hill, now almost without trace of shadow.

1867, June 9 & 10. Messrs Browning and Barnes, with a silvered glass reflector (*With*) 8¼-inch aperture, power 225?, saw a white nucleus on Linné, which Mr. Browning regarded as a *hill*.

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brighter than the adjacent surface of the M. Serenitatis. I recorded its brightness as 3°·1, that of the northern crater being 5°. See also Schmidt's observations on Aug. 20, *post*, pp. 19, 20.

* On Jan. 25, Herr Schmidt recorded a delicate black point, and east of, and close to it, a fine white summit. The diameters of these he respectively estimated at 200 and 300 toises; he did not give the height of the summit. Linné at the time being under the evening illumination, the positions of these objects were such as a small crater would present, the enlightened exterior rim being east of the dark spot. If the objects were the interior and rim of the crater seen afterwards by Secchi, and recorded as a remarkable hill by Schmidt on May 10, Schmidt's estimates on Jan. 25 and May 10 agree as to the diameter of the crater. This diameter, up to May 10, appears, from Schmidt's and Secchi's estimates, to have been under 0″·5.

† All the following remarks by Herr Schmidt are taken from that letter, which bears date, Athens, 1867, August 23.

1867, June 10. WOLF saw the little crater very distinctly; he speaks of it as very deep. Messrs. DAWES and KNOTT also saw it on this day.

1867, June 12. WOLF estimated the diameter of the little crater at 1″·0, or a little less.

"1867, Juli 8, 8ᵘ. [SCHMIDT.] Luft nicht still. Linné ein sehr kleiner deutlicher Hügel mit Schattenspur, diam. $\frac{1}{5}$ des nordwestlichen Craternachbars."

Translation.—1867, July 8, 8^h. Air disturbed. Linné a very small distinct hill, with trace of shadow, $\frac{1}{5}$ diameter of the neighbouring crater on the north-west [I $E^{\gamma\,3}$].

Herr SCHMIDT adds this note:—"Mit sehr mächtigerm Fernrohr und bei guter Luft wurde man viel *mehr* geschen haben; vielleicht Spuren des alten Craterwalls. Phase sehr günstig."

Translation.—Much more would have doubtless been seen with a much more powerful telescope and still atmosphere; perhaps traces of the old craterwall. Position of the terminator very favourable.

1867, July 9. The small crater was seen by Messrs. HUGGINS and BIRD. Mr. Huggins measured its diameter and found found it 1″·71.

"1867, Juli 12 [Qy. 22]*, 15^u. [SCHMIDT] Sehr unruhige Luft. Linné genau *in* der abnehmenden Phase: ein isolirter kleiner Punkt, d. h. ein ganz unbedeutender Hugel."

Translation.—July 22, 15^h. Air much disturbed. Linné exactly *on* the evening terminator; an isolated small point; that is, an utterly insignificant hill.

1867, July 22. TEMPEL. "Den Crater Linné habe ich am 22 Juli beobachtet. Es scheint als habe sich der kleine Crater ausgefullt; ja es ist jetzt sogar eine kleine Anhohe, ein kleiner runder Bergkegel an dessen Stelle sichtbar. Die angewandte Vergrosserung war eine 300-malige und die Nacht sehr rein."—Astronomische Nachrichten, No. 1656.

Translation.—I observed the crater Linné on the 22nd of July. It appears as if the small crater was filled up; nay, there is now a small elevation, a small round conical hill in its place. The power used was 300 and the night very fine.

"1867, August 7, $6^u{\cdot}5$–$8^u{\cdot}5$. [SCHMIDT.] Luft sehr unruhig: Phase bei Aristillus. Linné ein unbedeutender Lichtfleck, darin ein feiner Hugel von 1″ bis 2″ diam."

Translation.—Aug. 7, $6^h{\cdot}5$–$8^h{\cdot}5$. Air much disturbed; terminator over Aristillus. Linné an insignificant spot of light: in it a delicate hill from 1″ to 2″ in diameter.

1867, Aug. 20. Terminator bisecting Bessel. Mr. BUCKINGHAM observed the cone very distinctly, it projected a short shadow towards the W. The following measures were taken:—

Dark interior of the crater, mean of 8 measures....	0″·64
Exterior base of the cone, mean of 7 measures	2″·35

"Aug. 20, 11^h und 15^h. [Herr SCHMIDT.] Luft unruhig. Abnehmende Phase über Bessel. Linné ein matter Lichtfleck, etwas kleiner als der Crater S. Gallus: der westliche hügelartige Kern der Lichtwolke $=\frac{1}{10}$ S. Gallus. Die nordwestlich von Linné liegenden Crater hatten schon äussere Schatten. Der südliche dieser Crater war auffallend klein: kaum $\frac{1}{2}$ vom nordlichen Nachbar."

* At 15^h, Athens mean time of the 22nd July, Linné would be close on the evening terminator.

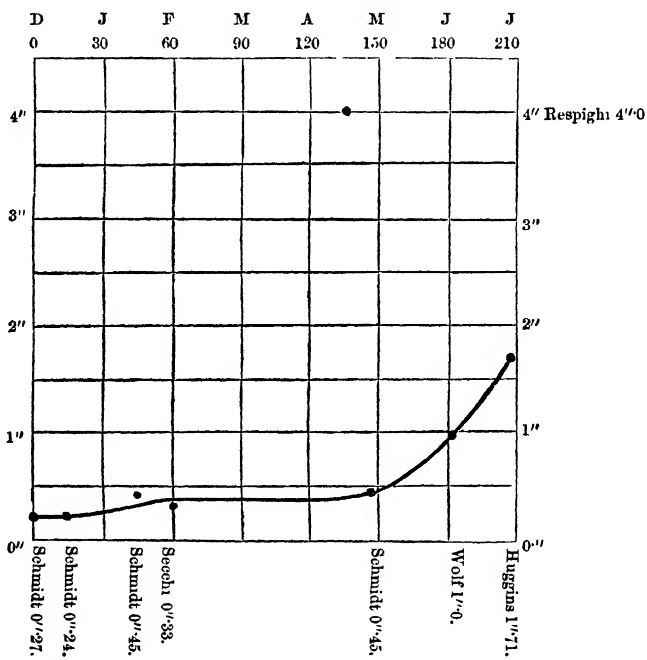
Translation.—Aug. 20, 11^h and 15^h. Air disturbed. Evening terminator over Bessel. Linné a faint spot of light somewhat smaller than the crater S. Gallus. The westerly hill-like nucleus of the light cloud = $\frac{1}{10}$ S. Gallus. The craters situated on the north-west of Linné had already exterior shadows. The southern of these craters [I $E^{\gamma 3}$] was remarkably small, scarcely $\frac{1}{2}$ of its northern neighbour.

1867, Sept. 18, 16^h. Mr. CARPENTER, of the Royal Observatory, Greenwich, observed the small crater with the great Equatoreal. His record is as follows:—"The definition was very good indeed: the crater-form distinctly visible: there was a delicate line of light running round the interior shadow, indicating the slightly elevated nature of the crater."

1867. Nov. 3, 5^h 30^m. Mr. PRINCE saw the small crater as a black point. See *ante*, p. 13.

1867, Dec. 4, 7^h 30^m, G.M.T. Mr. KNOTT had a very fair view of the small crater. The atmosphere was too unsteady to set the wires, but from the known thickness of the webs Mr. Knott estimated the diameter to be about 1″·5.

PROJECTION OF THE VALUES IN TABLE II.



The vertical lines represent intervals of 30 days; the horizontal, increments of 0″·5. Respighi's estimate, 4″·0, is not connected with the curve, as it does not fall in with the other estimates.

In the following Table the estimations of Schmidt on Dec. 13, 1866, and Jan. 25, 1867, were of the shadow-projecting hill and the fine black point (see foot-note on p. 18). These features were also seen by Buckingham. After Feb. 11, the small crater was the object generally observed. The exact date of Respighi's estimate is not given.

TABLE II.

Estimations and measures of the diameter of the small crater reduced to 29° 54′ 40″ = angular distance from the moon's centre.

Authority.	Epoch.	Date.	Seconds.	Eng. feet.	Fr. metres.
			″		
Schmidt............	1866·947	1866, Dec. 13	0·27	1918	584·7
Schmidt..	1866·983	1866, „ 26	0·24	1695	516·5
Schmidt............	1867·066	1867, Jan 25	0·18	1279	389·8
Schmidt............	1867·066	1867, „ 25	0·27	1918	584·7
Secchi	1867·112	1867, Feb. 11	0·33	2352	716·9
Schmidt......... ...	1867·353	1867, May 10	0·45	3197	974·4
Respighi			4·00	28226	8603·4
Wolf	1867·443	1867, June 12	1·00	7057	2150·9
Huggins	1867·518	1867, July 9	1·71	12067	3678·0
Buckingham......	1867·632	1867, Aug. 20	0·64*	4516	1376·6
Buckingham.....	1867·632	1867, „ 20	2·35†	16583	5054·5

OPINIONS.

In the preceding parts of this Appendix *facts* (as given by observation) only are mentioned. Since Schmidt's announcement of change several opinions have been expressed on the phenomena observed. It is manifestly desirable to avoid hazarding an opinion until the observations on the one hand have become sufficiently numerous to afford a solid basis on which to found a conclusion, and on the other have been so arranged and discussed that that conclusion may itself partake of the nature of a more general fact. Nevertheless, as the opinions that have been published may assist (in connexion with the observations) in arriving at a safe and general conclusion, they are given in the order in which they refer either to the early or recent observations.

OPINIONS OF THE WHITE SPOT IN SCHRÖTER'S TIME.

For SCHRÖTER's description of the spot *v*, see *ante*, pp. 3 and 4.

Mr. HUGGINS seems to regard this description as closely agreeing with the appearance of Linné at the present time, with the exception of the interior crater.—Monthly Notices, vol. xxvii. p. 298.

Professors D'ARREST and SCHJELLERUP agree with Mr. Huggins.—Astronomische Nachrichten, No. 1655.

SCHMIDT. "Der kleine Crater *v* daselbst entspricht am *nächsten* dem Orte des Linné."

Translation.—The small crater *v* corresponds *nearest* to the place of Linné.

RESPIGHI. "Il est positif que Schröter, dans ses *Selenotopographische Fragmente*, Table IX., représente cet objet avec une tache blanche, d'un diamètre presque égal à celui du cratère de Sulpicius Gallus, avec la trace d'un petit cratère, tel qu'on l'observe maintenant. et non comme quelques uns l'ont affirmé, sous la forme d'une grande tache noire; il est positif que le cratère a des dimensions à peu près égales à celles que lui assigne M. Schmidt lui-même, c'est-à-dire environ quatre milles de diamètre."—Bulletin Météorologique de l'Observatoire du Collége Romain, 31 Mai 1867.

Translation.—It is positive that Schröter, in his *Selenotopographische Frag-*

* The orifice of the crater. † The base of the cone.

mente, Table IX., represents this object as a white spot of a diameter almost equal to that of the crater Sulpicius Gallus, with the trace of a small crater such as we now observe, and not as some have affirmed under the form of a large black spot. It is certain that the dimensions of the crater are almost equal to those assigned to it by Schmidt himself, that is to say, about four miles in diameter.

WOLF. "D'après la note même de M. Schmidt, Schröter semble ne pas avoir vu Linné, au moins comme un des cratères principaux de la mer de Sérénité, bien qu'il en ait noté de plus petits."—Comptes Rendus, Séance du 17 Juin 1867.

Translation.—From the note itself of M. Schmidt, Schröter seems not to have seen Linné, at least as one of the principal craters of the Mare Serenitatis, although he has noticed some smaller (see *ante*, p. 4 *b*).

RECENT OPINION OF THE WHITE SPOT.—Mr. SLACK, writing under date of Oct. 11, 1867, says, "There can be no doubt that Linné varies in appearance, sometimes justifying the epithet 'cloudy,' at others gradually toning down from the bright central part to an edge difficult to define or discriminate from the adjacent portion of sea, and last night (see observation, *ante*, pp. 7, 8) clear at the margin and distinct from the sea." Mr. Slack adds, "But is this peculiar to Linné? I think not, but it must be considered in relation to other changes of tint and hue."

OPINIONS ON THE GENERAL RESULTS.

Herr SCHMIDT, 1867, Feb. 7. "Nachdem nun vier Lunationen hindurch die sorgfaltigste Prüfung dargethan hat, dass 'Linné,' in seiner Tagesperiode etwa 13 Tage lang als kleine Lichtwolke, *an der Lichtgrenze aber durchaus nicht als Crater*, gesehen wird, sondern zur Zeit sehr geringer Sonnenhöhen überhaupt ganz unsichtbar ist, halte ich jetzt, gestützt auf Thatsachen der Beobachtung, den Ausspruch genugend begrundet '*dass auf dem Monde gegenwartig noch Veränderungen eintreten, die durch den Wechsel der Beleuchtung nicht erklart werden können.*'"

Translation.—Now that after the most careful examination, continued through four lunations, has proved that Linné in its day-period, about 13 days long, is visible as a small white cloud, but *on the terminator not at all as a crater*, whilst at the epochs of very small sun-heights it is quite invisible, I regard it as satisfactorily established, relying on the facts of the observations, *that changes are now still taking place on the moon, which cannot be explained by the differences of illumination.*

Herr SCHMIDT, 1867, August 23. In a letter to Mr. Lynn of this date, before referred to, Herr Schmidt says, "*Alle Beobachtungen* lehren einfach desselbe, nämlich, dass jetzt an Stelle des vormals sehr tiefen und 5000 Toisen breiten Craters Linné, nur noch eine *nicht* vertiefte helle Fläche und ein kleiner Hügel gesehen werden."

Translation.—All the observations teach precisely the same thing, namely, that in the place of the formerly existing crater in Linné, which was very deep and 5000 toises wide, there can now be seen only a bright spot, *not* a depression, and a small hill.

FLAMMARION. "Si Linné avait eu cet aspect à l'époque où Beer et Mädler ont construit leur *Mappa Selenographica* il est impossible qu'ils l'eûssent indiqué comme ún cratère."—Comptes Rendus, tom. lxiv. (20 Mai 1867) No. 20, p. 1020.

Translation.—If Linné had had this aspect at the epoch when Beer and

Mädler constructed their *Mappa Selenographica,* it is impossible that they could have indicated it as a crater.

"On peut donc penser maintenant que notre satellite n'est pas un monde entièrement mort, et que des mouvements assez sensibles pour être vus d'ici s'accomplissent intervalles à sa surface."

Translation.—We are therefore able now to consider that our satellite is not an entirely dead world, and that movements at intervals on its surface are sensible enough to be seen from hence.

Padre Secchi, Comptes Rendus, tom. lxiv. 25 Fevrier 1867, p. 345.

"La grandeur de l'orifice du cratère était de $\frac{1}{3}$ de seconde au plus, et l'auréole était un peu plus large que *Sulpicius Gallus.* J'insiste sur cette comparaison, car elle fait voir que MM. Madler et Beer, dont j'employais la belle carte, n'auraient jamais figuré un cratère aussi grand et aussi bien fait que celui qu'ils assignent à Linné, pour une tache blanche comme celle qui existe à présent; en effet *Sulpicius Gallus* est actuellement beaucoup plus grand que le petit cratère qui forme le centre de la tache. Ce dernier est même encore plus petit que ces autres cratères qu'on indique seulement par des lettres, sans leur donner de nom, et qui sont répandus à grandes distances dans le *Mare Serenitatis.* "On ne peut donc douter qu'il y ait eu un changement, et il paraît probable qu'une éruption a rempli l'ancien cratère, d'une matière assez blanche pour paraître beaucoup plus claire que le fond de la mer qui l'environne."

Translation.—The size of the orifice of the crater was at most $\frac{1}{3}$ of a second, and the aureole was a little larger than Sulpicius Gallus. I insist on this comparison because it shows that B. & M. could never have figured a crater as big and as well marked as that which they assigned to Linné, for the white spot which at present exists; in fact Sulpicius Gallus is actually much larger than the little crater which forms the centre of the spot. This last is even smaller than those craters which are indicated merely by letters without names, and which are distributed at great distances in *M. Serenitatis.* It cannot be doubted that a change has taken place, and it seems probable that an eruption has filled the ancient crater with a material white enough to look bright against the dark ground of the sea.

Charcornac. "S'il est vrai, comme l'a décrit Lohrmann, que c'etait un cratère profondément sculpté dans la plaine, representant l'aspect d'un creux, rond comme un pot, il est incontestable que ce cratère s'est effacé et qu'il n'en est reste qu'une surface blanche."—Comptes Rendus, tom. lxiv. (20 Mai 1867) p. 1022.

Translation.—If it be true, as described by Lohrmann, that this was a deep crater sculptured in the plain and represented by the aspect of a pit, round as a pot, it is incontestable that this crater is effaced and that there remains nothing of it but a white surface.

"Une dernière éruption dans le vide efface donc ce cratère en comblant le creux et en annulant les ramparts en forme de bourrelet. Cet important phénomène montre que l'activité volcanique de notre satellite persiste encore."

Translation.—The last eruption therefore effaced the void of this crater in filling the pit and reducing the ramparts to the form of a hood. This important phenomenon shows that the volcanic activity of our satellite still continues.

Wolf. "En résumé, à part l'indication fournie par les cartes de Lohrmann et de Beer et Mädler, à laquelle on peut opposer la contre-indication de Lahire et de Schröter, nous ne possédons actuellement qu'un seul document positif sur le changement qu'aurait subi Linné: c'est l'affirmation de M. Schmidt que

ses notes et ses dessins de 1841 représentent cet objet autrement qu'on ne le voit maintenant."—Comptes Rendus, tom. lxiv. (17 Juin 1867).

Translation.—Résumé:—Apart from the indications furnished by the maps of Lohrmann and Beer and Mädler, to which we are able to oppose the contra-indication of Lahire and of Schröter, we actually possess only one positive document on the change which Linné has undergone: this is the affirmation of M. Schmidt, that his notes and his drawings in 1841 represent this object otherwise than as we now see it.

M. DE BEAUMONT. "Au surplus on doit désirer que les observations relatives à la permanence absolue ou à de très légères, altérations des accidents de la surface lunaire se multiplient, car une seule altération même très légère, suffirait si elle était bien constatée pour établir que la *vie géologique* encore dans l'intérieur de la lune aussi bien que dans l'intérieur de la terre."—Comptes Rendus, tom. lxiv. (17 Juin 1867) p. 1242.

Translation.—Moreover it is to be desired that observations relative to the absolute permanence, or to very small alterations of the details of the lunar surface, should be multiplied; for even only one very small change, if it were fully proved, would be sufficient to establish that geological life is still in the interior of the moon as well as in the interior of the earth.

RESPIGHI. "Je crois donc pouvoir conclure que le cratère n'a pas éprouvé de changement sensible ou du moins que les arguments produits en faveur de ce changement sont vagues et ne sont pas concluants."

Translation.—I therefore think that we may conclude that a sensible change of the crater is not proved, or at least that the arguments produced in favour of this change are vague and inconclusive.

I am greatly indebted to my friend Mr. Lynn, of the Royal Observatory, Greenwich, for his assistance in kindly translating the records and opinions of Foreign observers, and also in furnishing the additional observations by Herr Schmidt.

W. R. B.

Third Report of the Committee for Exploring Kent's Cavern, Devonshire. The Committee consisting of Sir CHARLES LYELL, *Bart.*, Professor PHILLIPS, Sir JOHN LUBBOCK, *Bart.*, Mr. JOHN EVANS, Mr. EDWARD VIVIAN, Mr. GEORGE BUSK, *and* Mr. WILLIAM PENGELLY (Reporter).

THE Reports presented by the Committee, in 1865 and 1866, render it unnecessary to give a detailed description of either the situation or the character of Kent's Hole. The Cavern may be briefly stated to consist of two parallel series of chambers and galleries—an eastern and a western; and to have two external openings or entrances—a northern and a southern. The entrances occur in one and the same low vertical cliff, on the eastern side of the hill in which the Cavern is situated. They are nearly on the same level, about 50 feet apart, from 180 to 190 feet above the level of mean tide, and about 70 feet above the bottom of the valley immediately adjacent.

The Committee have found it convenient to assign names to the various branches of the Cavern; and in order to avoid the risk of confusion, they have retained those which had been previously bestowed by the Rev. J. M'Enery and others.

The northern entrance opens, through a short narrow passage, into a

somewhat spacious chamber—the most northerly of the eastern series,—which Mr. M'Enery termed the "Vestibule," or "Sloping Chamber." It measures about 64 feet from north to south, and 28 from east to west.

From the north-western angle of the Vestibule, a gallery, about 32 feet long, and varying from 6 to 14 feet broad, extends in a north-easterly direction, and is known as the "North-east Gallery."

About 22 feet south of the entrance of this Gallery, an opening in the western wall of the Vestibule, about 35 feet wide, leads into the western series of galleries and chambers. So far as is known, this is the only passage connecting the two series.

A passage, about 22 feet in length and varying from 19 to 27 feet in breadth, which Mr. M'Enery termed the "Passage of Urns," leads out of the Vestibule southwards into the most spacious chamber of the eastern series, which, therefore, has been termed the "Great Chamber." It measures about 62 feet from east to west, and, where longest, 53 from north to south. In its eastern side is the second or southern entrance of the Cavern; and from its back or western wall—almost immediately opposite the entrance—there extends a *cul de sac* in a westerly direction, for about 29 feet, and varying in breadth from 15 to 10 feet. This is known as *the* "Gallery."

The Great Chamber opens southwards into an apartment measuring about 40 feet from north to south and 26 from east to west. From the fact that, during the last twenty years, Mr. Vivian has frequently lectured in the Cavern, and has on these occasions always taken his stand here, this apartment has received the name of the "Lecture Hall"—a designation which it is proposed to retain.

About 12 feet north of the junction of the Great Chamber and the Lecture Hall, a gallery opens out of the eastern wall of the former, in a south-easterly direction. Its width is about 7 feet at the entrance, and its length, which at present is undetermined, exceeds 30 feet. The entrance of a similar and parallel gallery occurs near the south-eastern corner of the Lecture Hall. In accordance with the names given them by Mr. M'Enery, they are respectively termed the "North" and "South Sally Ports."

The Lecture Hall opens southwards into a gallery about 17 feet wide, and at least 50 feet long; but as its further end is blocked up with large accumulations of stalagmite and stalactite, its true dimensions are at present unknown.

During the year which has elapsed since their Second Report was sent in, the Committee have continued their labours uninterruptedly; the Superintendents have made daily visits to the Cavern; the methods of excavation and investigation described in detail in the First Report, and which render it easy to define accurately the position of every object found, have been uniformly followed; the daily journal has been carefully kept; and monthly reports of progress have been regularly forwarded to the Chairman of the Committee.

From the commencement to the present time, the work has been carried on, under the direction and inspection of the Superintendents, by the same two workmen—Charles Keeping and George Smeardon—and the Committee have great pleasure in stating that nothing can surpass their zeal, industry, intelligence, and integrity.

The investigation naturally excites much interest amongst the visitors and residents at Torquay, and draws a considerable number of them to the Cavern. But, whilst every reasonable facility is afforded them for witnessing the operations, no one is admitted to those parts which are under examina-

tion unless accompanied by one of the Superintendents. The other branches, and these only, are shown to visitors by the guide appointed by the proprietor, Sir L. Palk, Bart., M.P. Such visits, however, can be made only when the Committee's workmen are present, by whom, and not by the guide, the keys are kept. In short, every care is taken to find all the objects really belonging to the Cavern; and every precaution to prevent anything being maliciously or mischievously placed in the deposits for the workmen to find.

Amongst the visitors during the present year, the Superintendents had the pleasure of receiving Captain Galton, Mr. Godwin-Austen, Mr. Gwyn Jeffreys, and Mr. Prestwich—all members of the British Association. They were conducted over the Cavern by the Superintendents, the mode of operation was fully explained to them, and they inspected a large and characteristic series of the fossils, as well as of the flint implements and other relics of human industrial art, which the Cavern has yielded.

Hitherto the labours of the Committee have been confined to the eastern series of galleries and chambers. Of these, the Great Chamber, the Gallery, the Passage of Urns, the Vestibule, and the North-east Gallery have been completely explored to the depth of 4 feet below the base of the Stalagmitic floor; to which, from the beginning, and as a first exploration, the excavation has been restricted. In the Lecture Hall, in which the workmen are at present engaged, considerable progress has been made. On its completion, it is intended to proceed to the gallery leading out of it southwards, and then to the Sally Ports.

Mr. M'Enery and the other early explorers carried on some part of their researches in a small portion of the Vestibule, and in the Lecture Hall. In the latter their works were probably on a somewhat larger scale. Unfortunately, instead of taking out of the Cavern that portion of the deposits which they had examined, they simply threw it on one side. The Committee have found it necessary to remove this disturbed material, and, in doing this, they have examined it with a care almost equal to that they bestow on the virgin ground. The result has been the discovery of a large number of fine specimens of teeth and other relics of the ordinary Cave mammalia, which were either unnoticed or neglected by the early explorers. Indeed, the largest Mammoth molar which the Committee have found occurred in these old workings. In order to the thorough investigation of cavern deposits, they must be removed without the cavern—partly to secure their complete examination by daylight, and also to prevent the commingling of disturbed and undisturbed soil. Great as may be the palæontological value of the specimens thus recovered, they can be of no service as evidence on questions of chronology or contemporaneity, as they are confusedly mixed up with objects belonging to many and widely-separated eras. Hence the Committee have carefully kept them apart from the specimens yielded by the ground which was unquestionably intact.

Except in one limited locality, to be noticed hereafter, the succession of deposits in the Cavern has been uniformly the same as that described in the two previous Reports, viz.:

First, or uppermost: Huge angular blocks of limestone.

Second: Black Mould, from 3 inches to upwards of a foot in depth.

Third: Stalagmitic Floor, varying in thickness from 3 inches to as many feet, but usually ranging from about 12 to 18 inches.

Fourth, or lowest yet found: Red "Cave-earth," with angular pieces of limestone, and occasionally rounded stones of kinds not derivable from the Cavern hill.

The excepted locality, just mentioned, was a part of the Vestibule, where a layer of black soil, apparently identical with that found almost everywhere above the Stalagmitic Floor, occurred *beneath* the floor. This layer, termed the "Black Band," was of irregular outline, and covered an area of about 100 square feet. It contained numerous bits of charcoal, and varied in thickness from 2 to 6 inches. Throughout about half of its area, it immediately underlay the Stalagmite, but elsewhere it was separated from the nether surface of the floor by a layer of ordinary Red Cave-earth, from 3 to 6 inches in thickness. At its nearest approach, it was 32 feet from the northern entrance; but as a great part of the intermediate ground had been broken up by the early explorers, it is impossible to say whether or not it formerly extended further in that direction. No trace of such material beneath the Stalagmite has been encountered by the Committee elsewhere. The floor immediately overlying the Black Band was loaded with fallen blocks of limestone, which were heaped one on another, and cemented by stalagmitic matter into a firm grotesque pile. This mass rose to the roof of the Cavern, and originally extended from its eastern almost to its western wall, thereby dividing the Vestibule into two separate chambers. Mr. M'Enery states that when he first visited the Cavern, before some of the impediments were removed, the only passage—on the west side—was "accomplished on all fours"*. A few years ago, Sir L. Palk had a more convenient passage cut through the pile on its eastern side. In the course of their researches the Committee have had to remove the entire mass.

The Black Mould overlying the Stalagmitic Floor has, during the last twelve months, yielded a large number of objects, such as were described in the Reports of 1865 and 1866, as well as several of which no examples had been previously found. Marine shells occurred everywhere in this accumulation, but in the Vestibule they were very abundant; those of the common oyster sometimes forming considerable heaps. It does not appear that in all cases they are necessarily to be regarded as evidence of a molluscous diet, since many of them, chiefly pectens and oysters, were certainly "dead" valves, as serpulæ and other small shells are attached to their inner surfaces.

Potsherds also have been numerous; but though some of them are of considerable size, nothing approaching a perfect vessel has been found. Judging from the varied forms of ornamentation on them, the pieces represent a large number of utensils. In most cases they are composed of a coarse clay, having an admixture of small stones.

Three spindle-whorls have been added to the collection. One of them is composed of coarse grit, and, unlike all the others which have been met with in the Cavern, its upper and lower surfaces are curved, and give it an oblate spheroidal form. Either for ornamentation or some unguessed purpose of utility, a groove has been cut round its greatest circumference. The two remaining whorls are of slate, and have numerous ornamental lines. In this connexion may be mentioned an Amber "bead," larger than some of the whorls, and in form resembling the grit whorl just mentioned.

Flakes of both black and white flint, but chiefly the former, have occurred in large numbers. During the last twelve months, not fewer than about 220 were found in this overlying Black Mould. Almost all of them were met with in the Vestibule, and it seems not improbable that, at least, some of the white specimens were dug up from the Red Cave-earth, and either lost or neglected by the earlier explorers.

* Cavern Researches, page 5.

Amongst the metal articles, there are a small bronze hook, an almost perfect bronze socketed celt, a halfpenny of 1806, and a sixpence of 1846.

The bone implements include an awl; a portion of some prismatic tool with rounded edges, and having on its surface a series of equidistant grooves or notches, such as to suggest that it may be part of a measuring rod; two bone combs, and fragments of two others. The combs belong to the same class as that described in the First Report—"having the form of a shoe-lifter, with teeth at the broad end." One of them is small, and rudely formed; the other is larger, and is highly finished. Two parallel lines traverse its surface, in a zigzag series, from end to end. At the end opposite that containing the teeth, there is a hole, as if for suspending it. This interesting object, the two fragments of combs, the grit spindle-whorl previously mentioned, a cockle shell, several potsherds, and a bone cut with some keen-edged tool were found in the south-eastern portion of the Great Chamber, where the overlying Black Mould was itself overlaid by a cake of stalagmite, which was attached to the wall of the cavern, from 1 to 2 inches thick, and which measured 7 feet from north to south by 6 from east to west. In many instances, stalagmite, fully as thick, had been found on the large blocks of limestone lying on the Black Mould; but this was the first, and, indeed, is at present the only example of such a cake formed immediately on the Black deposit itself. The interest attaching to it lies in the fact that there the lodgement of the Black Mould had closed before the formation of the stalagmite lying on it had begun; and that thus a certain amount of antiquity is secured for the objects which, as has just been stated, were found sealed up. In short, the geological evidence concurs with the archæological.

The overlying Black Mould has continued to yield a large number of bones of various mammals and birds, none of them probably belonging to extinct species. In this series, the most interesting objects found during the last year, are several portions of the human skeleton—including vertebræ, parts of lower jaws containing teeth, several loose teeth, and a skull. The skull was found about 6 inches below the surface, adjacent to the limestone rock, and immediately within the northern external entrance of the Cavern. The other human remains were met with in different parts of the Vestibule, and on different occasions. The first relic, indeed, the first vestige of the human skeleton met with during the present exploration, was part of a lower jaw containing two molars, and was found in December 1866.

The Stalagmitic Floor has presented its usual characters; being sometimes crystalline and extremely hard, and at others granular and comparatively soft. Not unfrequently it is composed of thin laminæ, alternately crystalline and granular. The Committee have still to report that comparatively few objects have been found in it. Amongst those which have presented themselves, are stones of different kinds, charcoal, flint flakes and cores, and remains of various animals, including the bear, fox, horse, and man. The stones, when not fragments of limestone, are commonly well-rounded, and were probably selected at the adjacent sea shore. One of the artificially formed flints has the appearance of being a fragment of a polished celt, or axe, and is the only specimen of the kind which has been found in the Cavern. Since the Second Report was sent in, a total of ten flakes and chips, of probably artificial origin, have been met with in the Stalagmite. The human remains are a tooth, and a portion of an upper jaw containing four teeth. They were found lying together in the Vestibule, about 30 feet from the northern entrance of the Cavern, and deeply imbedded in the floor, which was 20 inches thick. These interesting relics—the most ancient remains of man's osseous

system which the Cavern has yet yielded—were found on the 3rd of January, 1867.

The Black Band below the Stalagmitic Floor was extremely rich in objects, many of which are of great interest. They include bones and teeth of various animals, and traces of the presence of man. The list of animals represented in this Band includes the ox, deer (more than one species), horse, badger, bear, fox, *Rhinoceros tichorhinus* and *Hyæna spelæa.*

The indications of human existence are chips, flakes, cores, and implements of flint; bone tools; and bones partially burnt. The flint specimens form a total of 366 in number, or about ten on the average in every cubic foot of the material composing the Black Band. Though many of them are mere chips, and the majority are flakes, no inconsiderable number are more or less perfect *lanceolate* implements. By far the greater number are white, and have an almost chalky aspect and texture. Some of them are so extremely fragile as to break on the least pressure. It appears utterly impossible to suppose that they were introduced into the Cavern by other than human agency, or that they had ever been moved from the spot where they were primarily lodged. The bone tools are two, perhaps three, in number. One of them is an awl about 3¾ inches long, and cut at one end to a sharp point. It was found on the 27th of November 1866, beneath a floor of Stalagmite 16 inches thick, and perfectly intact and continuous in all directions, at a spot about 40 feet from the northern entrance of the Cavern. The second tool is a portion of a so-called harpoon, barbed on one side only, and about 3¾ inches long. It was found on the 17th of January, 1867. The third is of a nondescript and doubtful character.

With the exception of the Black Band—found only in one branch of the Cavern, and occupying a very limited space—the deposit below the Stalagmitic Floor is everywhere tolerably uniform in character—Red Cave-earth with angular fragments of limestone. The latter vary from mere splinters to blocks weighing many tons. Typically, this Cave-earth may be said to be composed of about equal parts of loam and stones; but in some places the latter greatly preponderate, whilst in others the former is most prevalent. Rolled stones, not derivable from the Cavern hill, occur here and there in every part which has been explored; but in those branches with which the Committee have been occupied during the last twelve months, they have not been so numerous as they were in the Gallery described in the Second Report. Blocks of stalagmite, the broken remnants of an old floor, continue to be abundant. They occur at all levels, both in the Cave-earth, and in the Stalagmitic Floor which the Committee found intact, and occasionally they project obliquely through the latter to the height of a foot or more. Many of them are of considerable size, measuring upwards of a cubic yard. Indeed one block, in the Lecture Hall, measured fully three cubic yards. So far as at present appears, no part of the Cavern is exempt from them, with the exception of that part of the Great Chamber extending from the southern entrance to 40 feet within it. From their first appearance, it was obvious that they were either of stalagmitic or of stalactitic origin. Their structure was strongly in favour of the former view, and this has been recently confirmed by the discovery of stones and bones incorporated within several of the blocks found in the Lecture Hall. It was stated in the First Report that matter of probably fæcal origin was frequently met with in the Cave-earth in the Great Chamber. A large quantity of this material, frequently forming considerable heaps, was found in the southern portion of this Chamber, which has been recently explored. With the exception of a few small pieces in the

Lecture Hall, nothing of the kind has presented itself in the other branches of the Cavern which the Committee have yet investigated.

In the Lecture Hall, as well as in the immediately adjacent part of the Great Chamber, a series of subterranean tunnels have occasionally been broken into by the workmen. They are more or less cylindrical, sensibly horizontal, and except in rare cases, upwards of 4 feet below the upper surface of the Cave-earth. Their size appears pretty uniform, and is such as would allow a fox, or perhaps a badger, to turn in them. Mr. M'Enery, who mentions them, thinks, and with much probability, that they are "Fox-earths."

Fragments of burnt bone have been found, here and there, in the Cave-earth in every chamber and gallery.

No other branch of the Cavern has proved to be quite so rich in bones as the Great Chamber, the larger portion of which was explored in 1865, and of which the particulars were given in the Report presented that year. Nevertheless, a very large number of teeth and other remains of the ordinary cave mammals have been exhumed from the Red loam during the last twelve months. It may be doubted, however, whether any important additions have been made to the list of animals given in the two previous Reports. As a provisional statement, the mammals represented by the vast collection which has now been made, may be still said to be the Cave-bear, Cave-lion, Cave-hyæna, Fox, Horse (probably more than one species), Ox, several species of Deer, the tichorhine Rhinoceros, Mammoth, and Badger. The condition of the bones is the same as that of those described in the previous Reports. Many of them are of an almost chalk-like whiteness, whilst others are discolored; some are more or less coated with films of stalagmite; many are merely fragments or splinters; a considerable number have been gnawed; those found immediately under heavy blocks of limestone are crushed; several are split longitudinally in such a manner as to betoken human agency: they are all characterized by a specific gravity greater than that of the bones found in the Black Mould overlying the Stalagmitic Floor; on the tongue being applied to them, they all more or less adhere to it; and in no instance have the elements of an entire skeleton, or anything approaching it, been found together. It is still true that, so far as is known, no bone or tooth of Machairodus, Hippopotamus, or Man has yet been found in the Cave-earth.

The Red earth has also yielded a considerable number of chips and flakes of flint during the last twelve months. The aggregate from the four foot-levels amounts to 238 specimens, which were thus distributed: 120 in the first foot-level, 53 in the second, 36 in the third, and 29 in the fourth or lowest. There are not amongst them any *ovate* implements, nor can the series as a whole, perhaps, be regarded as quite equal in interest to those which were described in the Reports of 1865 and 1866. The artificially wrought flints, inclusive of chips and flakes, which have been found in the Cavern during the last twelve months, form a total of 834; $=220$ from the overlying Black Mould, $+10$ from the Stalagmitic Floor, $+366$ from the Black Band, $+238$ from the Red Cave-earth.

Though the Committee have not on this occasion the pleasure of laying before the Association any highly-wrought flint implements, they have the gratification of producing tools formed of another material, and of a kind not previously found in the Cavern. Though it may be difficult to understand it, there is reason to believe that a few persons continue to be sceptical respecting the artificial character of even the best unpolished flint implements found in the Cavern or elsewhere. The Committee venture to entertain the opinion that the evidence which the last twelve months have put into their possession

renders it impossible for any one to doubt that Man occupied Devonshire when it was also the home of the extinct lion, hyæna, bear, rhinoceros, mammoth, and their contemporaries.

Of the tools alluded to, two have already been mentioned—the bone awl and the "harpoon" found in the Black Band, beneath the Stalagmitic Floor, in the Vestibule. As has been stated, in this same thin band there occurred, with the implements just mentioned, teeth of rhinoceros, hyæna, and other of the common cave mammals; and the story they tell is at once clear and resistless. These, however, are neither the only, nor the best bone implements which have been exhumed. Two others have been met with, and both of them in the Red Cave-earth, below the Black Band. One is a portion of a highly finished "harpoon," $2\frac{1}{4}$ inches in length, and differing from that previously mentioned, in the form of its point, and in being barbed on two sides. To use a botanical term, the barbs are "opposite," not "alternate," as is the case with many of the doubly-barbed implements of the kind found in certain French caverns. It is worthy of remark that whilst in France the same cavern has rarely, if ever, yielded both singly- and doubly-barbed "harpoons," an example of each kind has been found in Kent's Hole. This implement was met with on March 18th, 1867, in the Vestibule, in the second foot-level of Red Cave-earth. Vertically above these 2 feet of loam, there lay the Black Band about 3 inches thick, and containing flint flakes and remains of extinct Mammals; over this again came the Stalagmitic Floor, 18 inches thick, granular towards its base, crystalline and laminated towards the upper surface, continuous in all directions, unquestionably intact, and without fracture or crevice of any kind; and superposed on this, was the ordinary Black Mould with Romano-British potsherds. Like all bones found in the Cave-earth, the "harpoon," when applied to the tongue, firmly adheres to it. It has the condition which, from the spot it occupies, might have been looked for.

The second bone tool from the Cave-earth is a well-finished pin, $3\frac{1}{4}$ inches in length. It was found on the 3rd of January, 1867, and, like all the other bone tools, in the Vestibule. It was met with in the fourth foot-level below the Stalagmite—the greatest depth to which the excavation has been carried,—and in immediate contact with the crown of a molar of *Rhinoceros tichorhinus*. Vertically over this specimen there lay, in ascending order, 4 feet of Cave-earth; then the Black Band; over this the Stalgamitic Floor, 20 inches thick, perfectly intact, and continuous in all directions; this was surmounted by the Black Mould; and the whole was crowned with large blocks of limestone, cemented with carbonate of lime into a firm breccia, which reached the roof of the Cavern. The pin is well made, almost perfectly round, tapers uniformly from the head to the point, and has a considerable polish. It is, perhaps, more than probable that it was an article of the toilet, and hence the polish it bears, instead of having been designed, may have been the result of the constant use to which it was put. It may probably be said of its original possessor, as it has been of a more modern savage,

> "The shaggy wolfish skin he wore,
> Pinned by a polished bone before."

Though the Committee abstain from drawing any inference from the fact, since it applies to a limited number of objects only, it may be worthy of remark that the most highly finished implements, whether of flint or of bone, are those which have been found at the lowest levels.

Each of the great divisions of the Cavern—the Great Chamber, the Vestibule, and the Lecture Hall—in which the researches of the Committee have

been carried on, has been marked by some prominent facts. Thus, *ovate* flint implements have been found in the Great Chamber only, and there too the fæcal matter was almost exclusively met with. Bone tools and the Black Band presented themselves in the Vestibule, but not elsewhere; and the same branch of the Cavern was marked by the great numbers of chips and flakes of flint, and of blocks of old Stalagmitic Floor. Indeed the latter were so numerous and so piled on one another, especially on the western verge of the area occupied by the Black Band, as to assume the aspect of a rudely formed wall. In the Lecture Hall, extremely few specimens of flint occurred; but many of the blocks of old Stalagmite contained bones and teeth, the great majority of the latter being those of the Cave-bear. The blocks themselves were just as numerous in the other branches, but not one of *them* was found to be ossiferous.

Were we to speculate respecting the probable interpretation of the Black Band found beneath the Floor of the Vestibule—bearing in mind its very limited area, its position near the northern entrance of the Cavern and within the influence of the light entering thereby, its numerous bits of charcoal and of burnt bones, its bone tools and its very abundant, keen-edged, unworn, and brittle chips and flakes of whitened flint,—we might be tempted to conclude that we had not only identified Kent's Cavern as the home of one of our early ancestors, but the Vestibule as the particular apartment in which he enjoyed the pleasures of his own fireside: where he cooked and ate his meals; and where he chipped flint nodules, and cut and scraped bones into implements for war, for the chase, and for domestic use.

It is not improbable that some feeling of disappointment may rest in a few minds, and possibly something akin to rejoicing may find a place in others, at the fact that the labour which has been expended on this Cavern from the time of M'Enery to the present moment, has failed to detect beneath the Floor of Stalagmite any portion of the human skeleton. The results of these labours, however, do not justify either of those feelings, nor do they increase our confidence in negative evidence. Mr. M'Enery, at the end of the researches which, from 1825 to 1829, he carried on, was able to report the discovery of flint implements as the only indications of human existence. To the same effect were the subsequent investigations of Mr. Godwin-Austen; and, in like manner, the Torquay Natural History Society, at the close of their search in 1846, were unable to report further than that they had found man's flint tools mixed up, in the Red Cave-earth, with the remains of extinct animals in such a way as to render it impossible to doubt their contemporaneity. In 1865, the Committee appointed by the British Association commenced the exploration entrusted to them; and for some months they too were unable to report more than the discovery of flint implements.

In 1858, moreover, the celebrated cavern at Brixham, on the opposite side of Torbay, was discovered and methodically explored. The trustworthiness of the facts disclosed there may be said to have at once revolutionized the opinion of the scientific world on the question of human antiquity. The facts themselves, however, were identical with those which Kent's Cavern had yielded, at intervals, for upwards of thirty years,—flint tools inosculating with the remains of extinct mammals, in the Cave-earth, below a continuous floor of stalagmite. If ever merely negative evidence, then, could establish a proposition, it seemed safe to conclude that the only traces of man contained by the ossiferous caves of Devonshire were the so-called flint implements, about whose human origin some persons were still sceptical.

The Kent's Cavern Committee, however, were enabled in their First Re-

port, in 1865, to add the new fact that several pieces of burnt bone, as well as a stone having the appearance of a whetstone, and undoubtedly of distant derivation, had been met with in the cave-earth. Before the end of another twelvemonth, their attention had been arrested by a further phenomenon, and in their Second Report they remarked that "many of the long bones had been split longitudinally," and that it was "difficult to suppose that less than human agency could have so divided them." In this, their Third Report, they are able to advance another step, and to record the discovery of bone tools, about the character of which there can be no difference of opinion, which have the mineral condition characteristic of bones found in the deposit they occupied, which occurred with the remains of extinct mammals in soil indubitably intact, one of them at the greatest depth to which the excavation has been carried, and all of them beneath a thick unbroken Floor of Stalagmite, which has itself yielded remains of at least three of the extinct cave-mammals. These successive discoveries, after labours so protracted, are calculated to warn us not to place implicit confidence in merely negative evidence; to encourage the hope that the bones of man may yet be exhumed, though probably in sparing numbers only; and, should this hope be never realized, to justify even the most cautious in holding and avowing the belief that man was, in Devonshire, the contemporary of animals that had become extinct before the times of history or of tradition.

Again, that Kent's Hole was largely visited in Romano-British times, is testified by numerous and varied objects of that age, found in the Black Mould overlying the Stalagmite; and that the curious frequently made excursions to it during the last century, may be safely inferred from statements in the works of the local historians Polwhele and Maton. But waiving this point, and going no further back than the last forty years, it is capable of proof that, within that time, the Cavern was visited by more than ten thousand persons—including not only scientific inquirers, but large pic-nic, dancing, and Bacchanalian parties. All the visitors had to be accompanied by the appointed guide, who was invariably paid for his attendance. The payments were generally made in the Vestibule; and it might have been expected that, from time to time, money would have been lost, at least, in that part of the Cavern. Nevertheless, though the Black Mould has been most carefully examined, and has yielded a very large and most miscellaneous collection of objects, it was not until the close of twenty-one months that the labours of the Committee met with a pecuniary reward, in the form of a half-penny of George the Third. Two months afterwards, they had the happiness of finding a sixpence of forty years later date. Besides these, no coin has been met with from the commencement of the work to the present time.

Further, in their First Report the Committee reminded those who were disposed to attach importance to the fact that man's bones were not forth-coming as readily as his implements, that in the Black Mould, as well as in the Red Loam of the Cavern, the only indications of his existence were remnants of his handiwork; that pottery, implements varying in kind and in material, the remnants of his fires, and the relics of his feasts were numerous, and betokened the lapse of at least two thousand years; but that there, as well as in the older deposit—the Cave-earth below,—they had met with no vestige of his osseous system. This remained to be their experience, not only when their Second Report was sent in, but up to December last. Then the spell was broken by the discovery, in the Black Mould, of part of a human lower jaw containing two molars. This, as has been stated, was followed by the exhumation, from the same deposit, of parts of other jaws, a skull, and

other portions of the skeleton; and, as if to emphasize the fact, whilst these remains were being found, a fragment of a human upper jaw containing four teeth was, as previously mentioned, detected deep in the next older formation —the Stalagmitic Floor.

Lastly, during the past two years, the blocks of stalagmite previously mentioned have been found in every branch of the Cavern, and in all parts of the deposits. Their structure indicated that they were portions of an old floor, which, in some way not easy of explanation, had been broken up, and the fragments incorporated in the detrital accumulations subsequently lodged in the Cavern, and on which was formed that Stalagmitic Floor which the Committee found intact, and are breaking up every day. This view of the origin of the blocks was confirmed by the fact that a considerable remnant of an old floor still remains *in situ* in one branch of the Cavern, and which, under the name of "The Ceiling," was minutely described in the Report sent in last year. Nevertheless, as the existing floor very often graduates downwards into a breccia, and frequently contains bones, stones, and other extraneous bodies, it was reasonable to expect that some objects of the kind would be found attached to, or incorporated in the blocks if they were really fragments of an old floor which formerly spread over the Cavern. Accordingly, as the blocks presented themselves, all their surfaces were carefully examined, but no such trace or indication of their having once covered a detrital mass was to be seen on any of them. The more thoroughly to sift this question, hundreds of them have been broken by the workmen into small pieces, with the same invariable results—a structure indicative of stalagmitic origin, but without the disclosure of either bone or stone. At length, however, this large accumulation of negations was utterly set aside. On the 6th of last month (August 1867), one of these blocks, in the second foot-level of Cave-earth, and in the Lecture Hall, was found, on being fractured, to contain a bone; and thus any lingering doubt respecting its claims to represent an old perished Floor disappeared at once and for ever. Since that time ossiferous blocks have been found in the same Hall, at least two or three times a week.

The foregoing facts are calculated to stimulate to continued researches, and to encourage the hope that whilst a spadeful of deposit remains dislodged, a discovery may remain to be made.

The present state of the Manufacture of Iron in Great Britain, and its position as compared with that of some other countries. By I. Lowthian Bell.

[A communication ordered to be printed among the Reports.]

The object of such exhibitions as that which now occupies so large a share of public attention at Paris being to compare the results of human industry, it is not surprising that we have been favoured with many expressions of opinion on the relative merits of manufacturing science, as manifested in individuals as well as in nations.

These opinions are necessarily founded upon the information conveyed by the specimens of workmanship exposed for inspection; and therein, it is to be feared, is involved more or less of a serious fallacy. No one of any practical experience has difficulty in, or attributes the slightest skill to a manufacturing chemist for, exhibiting any of his usual products in a state of

great purity, provided he pays a little additional care in their preparation, and is regardless of the expense incurred in this exceptional mode of treatment. In like manner the iron-master, by selecting very pure ore and pure coke, may run from his furnaces an unusually fine specimen of pig iron, which, being puddled by his best men, hammered and rolled any number of times, gives, as it cannot fail to do, a sample of iron of great excellence.

If the question were asked, whether the articles we have the opportunity of examining upon such occasions convey in every case a correct idea of the average quality of the goods manufactured by and sold at the current rates of the exhibitor, it is much to be apprehended that such would not be found to be the fact.

The Industrial Exhibition at Paris has afforded an occasion for the iron-masters, engineers, and practical chemists of the United Kingdom to be told, on the authority of very influential names, and possessing, we are informed, very intimate acquaintance with the subject, that while foreign nations have in recent times been making wonderful advances in manufacturing science, little progress has been effected in this country. It will probably be beyond the power of any one individual to speak with a proper degree of confidence, from personal knowledge, on all the questions embraced in the general charge against our national industry. This paper will be confined to an attempt to institute a comparison between our position and that of our neighbours in the treatment of the ores of iron and their products.

This subject is selected because it is one to which the most pointed allusion has been made, and because in it any deficiency on our part would be the least excusable, seeing that nature has provided us with advantages which ought to afford the means of our competing with those nations which, by their superior intelligence and energy, are said to threaten us most.

If cost of production has to form no element in the calculation, it is clear results might be obtained which would lead to very erroneous conclusions in any comparative estimate. It is equally evident that any inherent excellence in his ores of iron would confer upon the smelter the power of producing a superior quality of metal, in doing which little, if anything, may be due to skill in manipulation. These circumstances are referred to merely to remind you of the difficulty in pronouncing, with certainty, upon a question where, in drawing a parallel, so many allowances have to be made. For the present, however, these disturbing influences will be disregarded, and attention only directed to the information conveyed by the numerous specimens of the metal to be seen at the Champs de Mars, and which by many have been assumed to proclaim our inferiority as manufacturers of iron.

No one who gives himself the trouble to study this department of the International Exhibition at Paris, can be otherwise than impressed with the pains the French makers have taken, not only to afford proofs of the quality of their produce by ingenious devices in showing fracture and tests of resistance, but also by a great number of sections of iron, which, from thinness and distribution of material, or great length, or with all these conditions combined, prove at once the chemical excellence of the metal, and the perfection of the machinery used in its mechanical preparation. After giving the most ample margin to the French, who in their own country would wish to do it all honour, and probably would possess some superior facilities in securing the necessary space for the display of their manufactures, an Englishman cannot but feel disappointed at the attempts, as exhibitors, made by some of our iron-masters, who have aspired to represent their own nation; indeed, nothing can excuse the careless indifference of one or two

who have intruded slovenly heaps of raw materials, intermingled with pieces of rusty iron, upon an occasion which may be looked upon as a state ceremonial of industry.

The practical man, however, notwithstanding these disadvantages, has there materials and opportunity enough, to enable him to pronounce an opinion with sufficient precision, on the question of quality of the samples submitted for examination. I have myself carefully and repeatedly studied all the great divisions of this important branch of metallurgical industry at Paris. I have done so alone, and in company with English and French engineers, iron-shipbuilders, and iron-masters, both British and foreign, including men of the greatest experience and knowledge of the subject,—and, supported by their concurrent testimony, I unhesitatingly advance the opinion that no evidence whatever is to be found there that this country occupies a position less conspicuous for excellenee of its produce than that of other nations. Of course, it is not pretended that in such a competition the four and a half millions of tons of British-made iron have to be brought into comparison with those 300,000 or 400,000 tons of the metal which it requires the collective power of every European nation to smelt from the purest and rarest known ores and charcoal, and which cannot be made or sold at much under double the price of our most esteemed brands.

It is of importance, in an inquiry like the present, to bestow especial attention to what may be considered the purely mechanical treatment of iron—to that treatment by which it is obtained in the various forms known in commerce. Those sections of bars which present mechanical difficulties in rolling, have those difficulties greatly increased by the presence of certain chemically combined impurities. A good skin, as it is called, and unbroken edges, particularly in some forms, may be accepted as a fair indication of quality of iron as well as of excellence of machinery employed. Judged by this standard, the French as well as some other nations, have every reason to congratulate themselves on the state of iron-manufacturing science in their respective countries, as evinced by some of the really marvellous pieces of iron they exhibit. One firm, for example, has sent solid rolled bars of double T iron 27 inches, and others 33 inches deep, by 30 and 40 feet long, each bar in both cases weighing forty-six cwts.; but the greatest *chef d'œuvre* in this way is a girder of the same form as the preceding, from the works of Chatillon and Commentary, 43 inches deep, with flanges 11¾ inches wide and web of 1¼ inch in thickness. This last achievement has not so far met with any practical application, but it is of value in showing engineers what can be done, and that when occasion requires it, they have it within their power to obtain perfectly solid masses of wrought iron of these large dimensions: at the same time it may be questioned whether, looking at the lengths which generally accompany the use of iron of such sectional strength, it will not be found more economical to construct the girder by rivetting plates or bars and angle-iron together. It should be stated that the Butterly Iron Company have for some time past rolled iron of this description, in a somewhat different way, for which they charge 40*s*. a ton less than the French quotations. Plates of iron, too, are exhibited, rolled so as to require no shearing along the sides, as has hitherto been practised. In many instances, such, for example, as in the construction of tanks, bridges, and other articles where a slight deviation from perfect soundness on the edge is immaterial, this mode of manufacture offers advantages by reason of the economy it effects. Against these proofs of efficiency of mill-machinery and skill in its use, may be placed the armour-plate, weighing eleven tons and a quarter, from the works of Messrs. Brown

and Company, of Sheffield, who have rolled plates of this kind weighing nearly twenty-five tons each. There are, it is true, pieces of forged iron in the Exhibition heavier than even this, but the difficulty our manufacturers had to encounter in transhipment would offer impediments in carriage not experienced by continental nations in sending objects to Paris, where size alone formed the test of merit.

Any one having any recollection of the state of metallurgical science at the time of the London Exhibition of 1851, will detect, in the means afforded him at the Champs de Mars, a wonderful change in the manufacture of steel. This is apparent in the number and dimensions of the objects now produced in that material. More recently even than sixteen years ago, the use of steel might almost be said to have been confined to small articles of cutlery; today, railway wheels, axles, heavy working parts of steam-engines, and even railway bars, absorb immense quantities of this form of iron. The manufacturers of other nations, in this substance as in iron, maintain their superiority as exhibitors, and probably at the head of all will be placed the name of Krupp (of Essen), from whose establishment has proceeded, among other admirable specimens of workmanship, the gigantic mass of cast steel in the shape of a piece of ordnance, weighing upwards of fifty tons.

We shall presently endeavour to discover to whose energy and inventive genius the credit is most due of having led the way in dealing with iron and steel of such extraordinary dimensions as are to be met with in our own days; and at the same time seek to establish what is the true position of different nations which have laboured in raising this remarkable branch of industry to its present colossal proportions.

In attempting this, the only mode of procedure is by reference to the history of the past, which shall be done in terms as brief as is consistent with clearness; at the same time it is obvious that in a manufacture involving both mechanical and chemical appliances, upon this occasion as well as hereafter, we shall be compelled to exceed those limits which ought to be observed in any section set apart for discussing a particular science. Some indulgence also must be extended to any minor inaccuracies in an endeavour to trace the progress of an art which owes improvements in its details to different individuals, whose position in questions of priority it is sometimes so difficult to determine.

It is not so very long ago that the attention of the Government of this country was called to the fact that the iron furnaces of that day threatened to place the kingdom in a position of considerable difficulty, from the rapid manner in which they were consuming the forests of certain districts, and, indeed, for a time, under the pressure of circumstances which arose, the make of iron, insignificant as it was, suffered considerable diminution. From this state of things the nation was relieved by the Darbys, in the midland counties, succeeding during the last century in applying upon a practical scale Dudley's discovery of the capabilities of mineral fuel being employed as a substitute for charcoal in the blast furnace. It is quite impossible to overrate the importance of this event in the history of the iron trade, because in localities where timber is only of little value, the rapid manner in which even a limited make consumes the forests near the smelting establishment, causes charcoal quickly to rise in price, owing to the increasing cost of carriage. This is easily perceived when it is remembered that in Styria and Carinthia something like twenty-five square miles of wood are stated as being required to supply the wants of each furnace, and that in consequence the best charcoal, owing to the distance it has to be conveyed, often costs nearly 50*s*. to 60*s*. per ton

before it reaches the iron works. Simple as this substitution of pit-coal for charred wood appears, it was a long time before the difficulties attending its introduction were overcome, and the prejudice against its use set aside—Dudley himself being in his grave long before the accomplishment of either. This cardinal improvement in iron-smelting brings us, without further change, down to about the beginning of the present century, when our blast-furnaces were running thirty or forty tons a week, and that portion of their produce which had to be converted into bar iron was obtained in this condition by means of the old "hearth," a most laborious, costly, and wasteful mode of treatment. In it charcoal was frequently the fuel still employed, and the small tilt hammer the only means possessed for reducing the malleable product to the state of the bar.

This was our position when our countryman Cort effected an entire revolution in the character of the operations carried on in our forges, by the invention of the rolling mill and the puddling furnace. The latter contrivance was subsequently greatly improved by Rogers abandoning the old sand bottoms used by its original designer, and by substituting iron plates protected by iron slag.

Fostered by the discoveries of Dudley and of Cort, the use of iron extended in every direction, rendering each subsequent improvement of increased importance, by reason of the enlarged field provided for its exercise.

It was thus a fortunate circumstance that the labours of James Watt, in connexion with the steam-engine, placed in the hands of the iron manufacturer the means of driving his new machinery, for which the water-wheels of our old forges were, in many instances, totally inadequate.

If the other changes which have been introduced in later times into our iron processes are to be considered as modifications and improvements only of what Dudley and Cort effected many years ago, that of Neilson in applying heated air to the blast furnace has been followed by results of such magnitude as to rank in importance with discoveries of the highest order. The effect Neilson's idea has had in reducing the consumption of fuel and the expense generally in smelting the ores of iron, is too familiar to all to require repetition here.

It would appear, however, that it is only to those greater and more sudden changes that the world at large seems to attach any significance; for, judging by recent criticism on the progress of metallurgical science in this country, the fact apparently has been overlooked that the iron-masters of Durham and North Yorkshire, within the last four years, have introduced great alterations in the character of their furnaces, and have succeeded in raising the temperature of the blast they employ to a point never contemplated by Neilson himself. These progressive changes have enabled their projectors to effect a saving in coal and an increase of produce, greater than the difference between those cold and hot blast furnaces still in common use in other parts of England.

Our rolling-mill engineers had kept pace with the constantly increasing requirements for malleable iron, until about a dozen years ago, when the example of the Emperor of the French created a demand for an article beyond the powers of any rolls then in existence. Possibly they were never applied to, owing to the belief then prevailing that hammered slabs of metal alone would satisfy the necessary conditions attending the protection of ships of war, by means of the so-called armour-plating—at all events it was by means of the steam-hammer (a French idea, it is said, originally, but indebted for its practical introduction here to Nasmyth) that we in this country,

in the year 1855, manufactured the iron for two floating batteries. To Mr. G. G. Sanderson, of the Park Gate Works, we owe the idea that rolled plates, by reason of their toughness, would be found superior in resisting shot to those of hammered iron; and to him, and to the owners of that establishment, is due the merit of having, in the same year, provided a mill and rolled the plating for a third floating battery, built by Messrs. Palmer on the Tyne*. The correctness of Mr. Sanderson's views have been justified by subsequent experiments. Sir William Armstrong's ingenious method of building up wrought iron so as to produce ordnance, having incredible powers of penetration, has called for greatly increased thickness in armour-plating. Manufacturers of this description of iron, however, by increasing the powers of their heating furnaces, mills, and other appliances, are now able to supply our naval yards and military establishments with material still more invulnerable than that formerly deemed sufficient as a means of defence.

It is this character of machinery which has enabled mill-owners here and abroad to handle such huge masses of wrought iron as have excited the admiration of all who interest themselves in such matters, and it is by means of the so-called universal mill designed by Mr. Arrowsmith that our friends in France are rolling their smooth-edged plates.

This hasty sketch is, it is hoped, an impartial account of what has been done in this country towards advancing the manufacture of iron to its present position.

As soon as the occasion arose, other nations profited by the wisdom our more matured experience had acquired, and every improvement in machinery or in process, found immediate imitators in each locality where the "forge Anglaise" had been constructed. It is mere repetition of a truth, admitted on all sides, that the modern blast-furnaces, forges, and mills abroad are in principle, and in most details identical with those of this country, and of such excellent construction as to have placed their owners on a level with ourselves so far as perfection of machinery is concerned.

It is, however, not to be expected that those conditions which prevail here should find an exact counterpart abroad; and wherever a deviation from things as they exist with ourselves occurred, the foreign iron-master was found, of course, adopting his mode of procedure so as to suit the change of circumstances. The chief difference between other countries and this is in the important matter of fuel. Here, regular lying beds of coal, generally of great purity, and in very accessible positions, have furnished us with abundant supplies of this element for the production of iron, and upon terms more favourable than those within reach of the continental iron-maker, who very frequently has to work with a combustible costly in itself, and containing a considerable amount of impurity. Long before it was thought of here, because the same necessity did not exist, our neighbours occupied themselves with devising ingenious methods of washing out the dirt contained in their coal, and afterwards in constructing ovens so as to coke the purified product with the least possible waste. They also conceived, and now practice on a very large scale, the idea of securing the advantages of large coal by cement-

* Since writing the above, I perceive Mr. Charles M. Palmer, in a paper on "Ship Building," read before the British Association in 1863, claims to have originated the idea that rolled plates would be found superior in power of resistance to those of hammered iron, and that it was at his request that the Park Gate Iron Company, then under the management of Mr. G. G. Sanderson, undertook to provide the necessary means for manufacturing the plating for the floating battery then in course of construction at Mr. Palmer's works.

ing together in very well-contrived machinery the improved small coal thus placed at their disposal. To meet the increased demand for pitch, which constitutes the cement used in this last-mentioned process, coke-ovens are now in use abroad for condensing all the products of distillation, both of a tarry as well as those of an ammoniacal nature. In like manner the excess of heat, which passes away from the puddling and balling furnace, instead of being permitted to escape, was made available in France for raising the steam for driving the forge and rolling-mill machinery; but perhaps the most elegant and interesting application of a waste product was that effected by employing the gases, which formerly flamed at the tops of their blast-furnaces, for a variety of purposes for which hitherto solid fuel had been used.

Now, it may be asked, were our own iron-masters indifferent spectators to those valuable ameliorations contributed by other nations to an art in which Britain might be supposed to occupy the first rank? The answer is, that no sooner did a change in the price of our fuel enable them to adopt, with profit, the purification of coal and the improvements in its conversion into coke, than both processes were imported into this kingdom; and at the present day there is scarcely an iron-work in it of any consideration, where the machinery is not driven by the waste heat from its own furnaces in the manner suggested by the example of our neighbours. As regards the use of the blast-furnace gases, not only have our furnace-owners availed themselves of the lesson taught them by foreign industry, but the mode of collection has been so improved as to afford in many cases results better than those obtained by the original inventors. At this time not less than 500,000 tons of coal are annually saved in the Cleveland iron district alone, by the state of perfection to which this admirable discovery has been carried.

For many years past such are the advantages possessed by this country for the economical working of metals that, although the raw material for the finer kinds of steel had to be imported from other nations, we have been able, notwithstanding, from our position in other respects, to rank first as manufacturers of this modified form of iron. The rapid speeds attained on our railways, and the great strain to which the machinery there, as well as on other occasions, is exposed, has rendered increased strength of material, combined with lightness, an object of the highest importance. Metallurgists have thus been led to devise some more ready and less expensive methods of producing steel, this substance being, as is well known, possessed of the desired qualities, unequalled by any other known condition of iron. It is needless to dwell on the various projects which have been suggested for securing this desideratum, inasmuch as every one appears to have been driven out of the field by that last great discovery of Bessemer, the success of which still maintains for this nation its old position in an industry in which it has laboured so incessantly and to such good purpose. It is true in Prussia there exist gigantic steel-works (those of Krupp and others) where the process is carried on by methods confined, it is alleged, to themselves. Whatever these methods may be, they are not of that character to have prevented the directors of the establishments named from adding the converters of Bessemer to any appliances or modes of procedure of which they have the merit of being the original inventors.

In concluding this endeavour to trace, in its main features, the progress of the manufacture of iron, I may be permitted to mention that, during a personal acquaintance with the works of this and other countries, extending over twenty-five years, I can detect no change in the relative position of ourselves and continental nations as iron manufacturers. No doubt, abroad, the

production of this metal has increased immensely in late years, but this is due to circumstances entirely disconnected with any greater comparative proficiency than that possessed in former days. During the whole of the period named, the existing iron-works were equal to similar establishments of our own, and certainly those which have been constructed of late have no pretensions whatever to be otherwise considered.

The present depressed state of our own iron trade and its recent extension abroad, have probably countenanced the idea that the distress here has some connexion with the nature of the progress of the continental manufactures. It becomes, therefore, not unimportant to ascertain upon what grounds such a supposition is based.

The first question to which an investigator would address himself in such an inquiry, is the powers possessed by different localities for obtaining the raw materials required in the works themselves. Immediately connected with this matter is the right of ownership in the minerals. In foreign countries generally, this charge is one of trifling extent, which is far from being the case with ourselves, where, on a ton of pig iron worth about 45*s.*, the manufacturer will contribute about 4*s.* for royalty to the owner of the soil; while on the continent one-fourth of this sum will sometimes cover all that is levied for the right of working the coal and ironstone for the same quantity of iron. In spite, however, of these disadvantages, and of others related to the extraction of coal in Britain, the purity of the produce of our collieries and the favourable conditions under which it occurs, conduce to place this country, so far as fuel is concerned, in a position rarely approached by that of any European nation. When the ores themselves have to be considered, much greater difficulty meets us than is experienced in the case of coal. In addition to price we have to look to the percentage of iron they contain, and also to the widely different qualities of the metal they yield. Any very lengthened exposition of facts, however, would not only be tedious, but would lead to some confusion. We must therefore content ourselves with the statement that the advantages in cost and quality of iron ore possessed by Scotland, Staffordshire, Wales, and the West of England, are all to be severally met with on the continent, and from this general statement we cannot even except the Cleveland ironfield, for a similar deposit is extensively wrought in the Moselle district, and at a price fully below that paid in North Yorkshire.

Conditions, however, immediately connected with the economy of producing pig iron, obtain in this kingdom which are seldom met with abroad. The ore which has to be smelted is here either often got from the same strata which furnish the coal, or the space of country which separates the two is inconsiderable. The distances, on the other hand, which as a rule intervene between the coalfields and the iron mines on the continent, are so great as to prove a source of considerable outlay for conveying the produce of the one to the other.

With regard to the application of science to those sections of our operation which are dependent on chemical action, viz. the blast-furnace and the puddling process, the iron-master in other countries, as here, can only lament how little chemistry has hitherto been able to effect for either. The labours of Karsten, Scheerer, Bunsen, Tunner, and others, have thrown great light on the intricate and interesting problems connected with the working of our blast-furnaces. We have been informed by means of their investigations, and those of philosophers in this country and elsewhere, that differences we know to exist between certain qualities of iron were due to minute quantities

of silicon, phosphorus, or sulphur; but these experimenters have never taught us how to separate, economically, those almost infinitesimal amounts of substances, to rid our produce of which has defied their science and our practice.

Both on the continent and in this country, the success attending the use of the blast- and puddling-furnaces rests, in a great measure, with the workmen; and so far as waste of material, quality of produce, or any other test, enables one to judge of the results, it is as absurd to impute any superiority to either side, as it is impossible to find a higher degree of science, where both British and foreign artisans are equally uninstructed in respect to the true nature of the process under their control.

It may be well, at the same time, for our own workpeople to know that, although we had the start in this particular field of industry, there is not one department, from rolling the finest wire iron and the thinnest tin plates or hoops, to turning out the largest rails or heaviest armour plating, in which these operations are not performed quite as well by foreign labour as by the most expert rollers in the best mills in this country.

Reverting now to the relative facilities enjoyed on the continent and here in the manufacture of iron, it may be remembered that ours have been stated to lie in the possession of mines yielding coal upon more favourable conditions, and in the more convenient geographical distribution of our minerals. To the last may be added the easier transport of our manufactured produce to a seaport, due to the insular character of our country. Against this we have to set the lesser charge for royalties on coal and ironstone abroad, together with the fact, not previously noticed, that their railway transport is somewhat less costly than with us, reckoned for equal distances. The saving thus effected in France and other places cannot account for the disappearance which occurs, to a great extent, of the effect of those natural advantages, economically speaking, placed at the disposal of the iron manufacturers of this kingdom.

So far as a careful examination of iron-works producing above one-half of the collective make of France, Belgium, and the Ruhr district has enabled Mr. Lancaster, the iron-master of Wigan, and myself to judge, this is due neither to greater science possessed by the iron-master, nor to greater skill on the part of the workmen, but is wholly to be ascribed to the cheaper rate at which labour is obtained abroad than with us.

To ascertain as exactly as possible whether the foreign artisan could, from surrounding circumstances, dispose of the work of his hands upon cheaper terms than persons of his own condition are able to do with ourselves, I made myself acquainted, while in Sweden, France, Belgium, and Prussia, with the cost of the necessaries of life consumed by the working population. It is almost superfluous to say that the creation of additional industry abroad, and above all, the equalizing effect on prices by the introduction of free trade here, have entirely changed the aspect of affairs, and that, in consequence, provisions are at least 20 to 30 per cent. dearer to the foreign labourer than they were twenty years ago. Without going into details, it may suffice to say that animal food is only 3 per cent. cheaper in the chief seats of continental manufacture than with us—while house-rent and clothing are about the same in value with both. On the other hand, at the present moment, wheat is fully lower in England, and our own workmen do not pay half the price charged to persons of their own class abroad for firing employed for domestic use.

Notwithstanding this almost perfect equality in the cost of the necessaries

of life, labour on the continent is, in very many instances, 30 per cent. below the price it commands in this kingdom. This estimate is based on calculations where there is no room for any great difference in the nature of the work performed, common brick-making being assumed as one of the standards of comparison. In the manufacture of iron itself this difference is occasionally still more remarkable. Colliers, miners, mechanics, iron workers, in short, every one engaged in the process appear to be receiving 20 to 30 per cent. below the rates current in this country, and in some cases double, and more than double, the wages paid abroad are earned in our English iron-works. The iron-masters here have endeavoured to meet what would be an intolerable burden in the production of an article made up almost exclusively of labour, by adopting means for reducing its amount, often considerably in advance of those met with in foreign establishments. After all this has been done, however, it leaves us to contend with an extra charge of at least 15 to 20 per cent. in the item of wages, which, in the majority of instances, will be found to annihilate any advantage of position we may otherwise possess.

It must be clear that when this country has to compete with foreign nations in articles involving a still higher amount of labour, such as steam-engines and other kinds of machinery, the difference in wages just alluded to acts still more prejudicially to the advancement of our national industry.

To the political economist, the question of the future of our iron trade, from its magnitude, cannot fail to be one of great interest. The extent also to which steel has lately taken the place of iron in the arts, necessarily confers upon this material a conspicuous position in any consideration he or the metallurgist may bestow on the subject. This becomes more necessary from the fact that only a very limited number of ores are capable of affording iron of the necessary quality for the production of steel, by any of the processes now in existence. It is of importance, therefore, to know that even in Austria, Sweden, and Germany, where suitable mineral for this purpose does occur, it is found in quantities quite as limited in extent as prevails with us; in France also, where preparations for manufacturing Bessemer steel on a very extensive scale are being made, large quantities of ore are required to be imported from Algeria and elsewhere to obtain that kind of pig iron which their own minerals alone are found incapable of supplying.

The great strength, however, of our own position as iron manufacturers, it appears to me, must be sought for in these incomparable fields of coal which constitute so important a feature in our mineral wealth. I am very sanguine that the advantages thus secured to us will, notwithstanding present difficulties, maintain the iron trade among the most prominent of our national branches of commerce. This conclusion is arrived at from a consideration of the various circumstances connected with the use of coal and the means possessed by different nations of satisfying the constantly increasing demands this use creates. In Great Britain we raise annually something like 100,000,000 tons of this mineral, of which 10,000,000 are exported, and about 20,000,000 are devoted to the use of our iron-works, leaving thus 70,000,000 of tons for consumption in other descriptions of manufactories, purposes of locomotion, and for domestic use. In France and Belgium together, less than one-fourth of our production is obtained, and this only by great exertions being made to obtain the largest possible quantity their mines are capable of affording. After satisfying the requirements of the iron-works of these two countries, not much over 15,000,000 of tons would remain for carrying on those operations in which, with a smaller population, we are

consuming 70,000,000 tons of coal. Now, when we remember the various purposes to which coal is now applied, and where even a considerable augmentation of price will not preclude its use, we must at the same time perceive the serious effect any great change in the value of fuel must exercise on the production of an iron railway bar requiring five or six tons of coal for its manufacture. In reality, this disproportion between the value of coal and iron as compared with this country is already perceived abroad, where, notwithstanding greater mining difficulties than we have to contend with, fuel commands a price sufficient to cover this, and also leave a greater margin of profit than falls to the share of the coal owner in this country.

Favoured thus, as we undoubtedly are by nature, there seems nothing wanting for our success in this noble branch of manufacturing science than a continuance of that unflagging spirit of enterprise on the part of the masters, and the exercise of that operative skill on the side of our workmen, which is still unsurpassed in any iron-producing country of Europe; but in this alliance a correct knowledge by both of the competition we have to meet, and a thorough belief in the inseparable union of the interests of each, are indispensable.

Third Report on the Structure and Classification of the Fossil Crustacea. By Henry Woodward, *F.G.S., F.Z.S., of the British Museum.*

Since I had the honour to submit to the British Association my last Report on the Structure and Classification of the Fossil Crustacea, the first part of my monograph on the *Merostomata* has been issued by the Palæontographical Society. About seven more plates are already prepared for the second part, of some of which I am enabled to exhibit proofs.

The magnificent collection of remains of this remarkable group of Crustacea from the Devonian of Forfarshire, belonging to Mr. James Powrie, F.G.S., of Reswallie, are on view in the Volunteer Drill Hall.

A fine series, comprising several new forms, from the black shales (Uppermost Silurian) are exhibited at the present Meeting (Panmure St. Chapel) by Mr. R. Slimon from Lesmahagow, Lanarkshire, and are worthy of a careful inspection by all who are interested in geology.

In the immediate neighbourhood of Dundee, at Montrose, at the University of St. Andrews, at Arbroath, at Rossie Priory, and in the Watt Institution in the town itself, some of the best specimens ever yet found of the remains of *Pterygotus* are to be seen; whilst Balruddery Den, Carmyllie, and the quarries in the Sidlaw Hills, exhibit the "Arbroath paving-stones" and overlying fissile shales, whence these remains were procured.

Among the new forms which have been obtained by Mr. Slimon in his exploration of the shales of Logan Water, are some almost entire remains of a form allied to *Pterygotus punctatus* (called by Mr. Salter *Pt. scorpioides* *), which prove it to be an *Eurypterus* and not a *Pterygotus*. Another new form allied to *Pt. bilobus* and *perornatus*, but having the anterior segments much broader and shorter, and with a somewhat different form of thoracic plate,

* A MS. label bearing this name is attached to a specimen of a portion of this same species in the Museum at Jermyn Street.

has been met with. It will be needful to modify the specific name of *Pt. bilobus*, as the new form, and *perornatus*; both have a bilobed telson likewise.

If the name is retained, it must be applied to all three forms thus:—*Pt. bilobus*, var. *inornatus*; *Pt. bilobus*, var. *crassus**; *Pt. bilobus*, var. *perornatus*.

In the Quarterly Journal of the Geological Society, vol. xxii. part 1, February 1867, p. 28, and in the British Association Report for 1866, p. 180, and Sections, p. 79, I pointed out the affinities of the *Limulidæ* with the *Eurypteridæ*, and in the first-named paper I recorded all the forms then known which tended to confirm their alliance.

I have now to notice a new genus from Lesmahagow, Lanarkshire, which offers further evidence in confirmation of the correctness of the above-mentioned classification.

It is a small Limuloid form†, the carapace of which measures only 6 lines in breadth and 2 in length, having 5 thoracic and 3 abdominal segments, all of which appear to be free and distinct. The telson is unfortunately wanting, the specimen being close to the border of the matrix.

This little form carries the *Limulidæ* back in time from the Coal-measures to the Uppermost Silurian, a great and important extension.

I shall take an early opportunity to describe this form in detail, and to work out its relationship to *Belinurus* on the one hand and *Hemiaspis* on the other.

New Lower Lias Crustacean from Barrow-on-Soar.

A new Crustacean, obtained some years since by Sir Philip Egerton, Bart., M.P., from the Lower Lias of Barrow-on-Soar, has since been also found by Mr. Charles Moore, F.G.S., near Bath. It is quite distinct from every other form which I have examined from the Lias or Oolite. Its nearest analogue is the recent *Atya scabra* of Leach, from South America. The limbs are monodactylous and extremely rugose; the antennæ are rigid, and the basal joints thick and spinose, resembling in these points of structure the genus *Palinurina*. The rostrum is short and curved downwards. The carapace was extremely thin, and less chitinous than in the genera *Aeger* and *Penæus*, it is therefore more easily destroyed or distorted.

I propose to name this new form *Præatya scabrosa*.

Upper Lias Crustacea from Ilminster.

Having been favoured with the loan of a large series of specimens for examination from the Upper Lias of Ilminster, collected by Mr. Charles Moore, F.G.S., of Bath, I have been enabled to add a considerable number of genera and species to our list of Liassic Crustacea.

The two species of *Eryon*, *E. antiquus* and *E. Moorei*, have been already noticed by me from this locality (see Quart. Journ. Geol. Soc. vol. xxii. p. 499, pl. 25, fig. 3).

I have since determined the following genera and species, which will be described at length in a paper by Mr. Charles Moore on the Ilminster Lias, now in preparation‡:—

* This interesting form of *bilobus* exhibits in one instance well-preserved *branchiæ*, to which attention was called, and drawings of which were shown by Mr. Woodward. They will be figured in the Palæontographical Society's Monograph on the *Merostomata*.

† The original specimen was exhibited of this, and also figures and specimens of the other forms from Mr. Slimon's collection, believed to be new.

‡ See the Proceedings of the Somersetshire Archæological and Natural-History Society vol. xiii. Published November 1867. Taunton.

1. *Eryon*, Desmarest.
   —— *antiquus*, Brod. sp.
   —— *Moorei*, H. W.
2. *Palinurina*, Münst.
   —— *pygmæa*, Münst. Upper Lias, Ilminster.
   —— *longipes*, Münst. Upper Lias, Ilminster.
3. *Penæus*, Fabricius.
   —— *latipes*, Oppel. Upper Lias, Ilminster.
4. *Eryma*, Meyer.
   —— *elegans*, Oppel. Upper Lias, Ilminster.
   —— *Greppini*, Oppel. Upper Lias, Ilminster.
   —— *fuciformis*, Oppel. Upper Lias, Ilminster.
5. *Hefriga*, Munster.
   —— *Frischmanni*, Oppel. Upper Lias, Ilminster.
6. *Glyphæa*, Meyer.
   —— *Heeri*, Oppel. Upper Lias, Ilminster.
7. *Pseudoglyphæa*, Oppel.
   —— *Winwoodi*, H. W. Lias, Weston.

(Figures and specimens of these new species were exhibited.)

The above list shows an addition to our Liassic Crustacea of seven genera, and probably nine species new to Britain.

It is extremely interesting to notice so many forms common to our Lias and to the Lithographic stone of Solenhofen in Bavaria.

The persistence of such forms as *Eryon*, *Eryma*, and *Glyphæa* through the whole Oolitic series seems clearly to demonstrate that having escaped total extinction in the Lower Lias sea, they migrated from time to time to more favourable areas, and thus were enabled to live on during the periods of time represented by the long series of deposits from the Lower Lias to the Lithographic stone, in which so many examples are found fossil.

Oolitic forms of Decapoda Brachyura.

The genus *Prosopon* was established by H. von Meyer for certain minute forms of Crustacea from the Upper White Jura of Œrlinger Thal, and other localities in Germany, of which he has described 29 species (see Palæontographica for December 1860, vol. vii.). In addition to these he has described 1 species from the Lower Oolite, 3 from the Coral Rag, and 1 from the Neocomian.

Amongst them, however, are placed forms belonging to a widely different genus in no way related to the *Corystidæ*.

In Professor Bell's monograph on the Crustacea from the Greensand and Gault (Pal. Soc. Mon. 1862) he has figured and described one of these, and has correctly referred it to the *Pinnotheridæ*, under the generic name of *Plagiophthalmus*.

This genus would probably include the following species of H. von Meyer:—*Prosopon hebes*, *P. simplex*, *P. rostratum*, *P. spinosum*, *P. elongatum*, *P. depressum*, *P. obtusum*, *P. læve*, *P. sublæve*, *P. punctatum*, *P. Stotzingense*, *P. tuberosum*.

The following are doubtful: *P. insigne*, *P. æquilatum*, *P. marginatum*, *P. grande*, *P. excisum*, *P. lingulatum*.

For the remainder the generic name *Prosopon* should be retained, viz.: *P. aculeatum, P. ornatum, P. torosum, P. Heydeni, P. æquum, P. paradoxum.*

To this last division I have now the pleasure to add a new British species from Stonesfield.

This form was first noticed by Professor Morris, F.G.S., who obtained an imperfect carapace many years since; it was next observed by Mr. Samuel Stutterd, of Banbury, but likewise in an imperfect state. The perfect carapace now exhibited was kindly lent me by George Griffith, Esq., M.A., the Assistant-General Secretary of the British Association. All these three specimens are from Stonesfield, and they add another new genus to our list of British Oolitic Brachyura. I propose to name it *Prosopon mammillatum.*

New Fossil Land-Crab from the Lower Eocene.

Lastly, I wish to call attention to a new genus of Crustacea from the Red Marl of the Plastic Clay, High Cliff, Hampshire, and is, I believe, the first discovered example of a British land-crab, or shore-crab, yet met with. Its oblong quadrangular-shaped carapace, with obtusely rounded anterior angles and short blunt rostrum, remind one immediately of the *Ocypoda.* In addition to this, the eyes have extremely elongated peduncles, which are seen preserved in the fossil, lying in the groove along the fronto-orbital margin of the carapace, as in the recent genera *Gelasimus, Macrophthalmus,* and *Ocypoda.* The hands are both small; and from this, as well as from the very broad posterior border of the carapace, I infer that this is a female example, as in most of the recent species of *Quadrangulares* the male has one hand enormously developed for burrowing, whereas the hands of the female are both small and very feeble. The other limbs are, like those of the recent species, well formed for rapid movement along the ground. I propose to name this interesting little Crustacean *Goniocypoda Edwardsi,* in honour of the great French carcinologist to whom science is so much indebted*.

Report on the Physiological Action of the Methyl Compounds. By Benjamin W. Richardson, *M.A., M.D., F.R.S.*

In the present paper I produce the fourth of a series of Reports which I have had the honour to prepare for the British Association. The Reports have all had relation to the physiological action of bodies of organic type. The first Report treated of the action of the substance known as nitrite of amyl. The second was on amylic alcohol, acetate of amyl, and iodide of amyl. The third was on the nitrite of amyl as a remedy, and the action of the amyls as antiseptics; it included also notes of a research on the physiological action of absolute ether, hydrofluoric ether, acetate of ethyl, and nitrite of ethyl.

As the matter of the present Report is long, I shall not attempt to recapitulate at any length the results of previous Reports; I shall be content to offer as the more salient points the following facts:—

In respect to the amyls—

1. Nitrite of amyl was found to be the most active known excitant of the circulation.

* See Geol. Mag. Dec. 1867, vol. iv. p. 529, pl. 21. fig. 1.

2. All the compounds of amyl which were studied were found to modify in a singular manner the motive animal power.

3. One compound, amylene, is an anæsthetic.

4. All the amyls were found to be antiseptics; and acetate of amyl, it was suggested, might probably be used, on an extensive scale, for the preservation of animal substances.

In respect to the ethyls—

1. Pure oxide of ethyl was found to be the best and safest anæsthetic for general anæsthesia.

2. Hydrofluoric ether was found to be a most powerful agent for the destruction or resolvency of living animal tissues.

3. Nitrite of ethyl was discovered to possess an action similar to that of the nitrite of amyl, but with this striking difference in young animals,—that when they are made to receive it until they seem to be quite dead, they will remain as if dead for eight and even ten minutes, and will then faintly recommence to breathe, the heart following in its action; this condition, looking like an actual return of life, will sometimes last as long as half an hour, and will then gradually cease, the animal lapsing into actual inertia or death.

Such are a few of the facts elicited by these preceding researches; but as the Association is always anxious to learn what practical results have been obtained from its works, or from works performed under its auspices, I shall be pardoned if I refer to one or two of the results that have followed upon the present series of Reports.

The experimental truths which have been brought out in regard to the nitrite of amyl have led to the application of this substance to the alleviation of human suffering. Dr. Heydon of Dublin has used the nitrite with advantage in the treatment of cholera, in the later stages of the malady. Diluted with ether in the proportion of 5 per cent., the nitrite has been shown to exert a marked controlling influence over painful spasmodic breathing; and I hear that Dr. Brunton, of Edinburgh, has resorted to it with great success in the treatment of one of the most terrible of all maladies, cardiac apnœa, or angina pectoris.

The Report last year on ether, although written very briefly, has excited much practical interest both here and in America. It has led to the introduction into medicine of a more stable and reliable ether compound; and it has caused many surgeons to return, with satisfaction, to the use of ether as an anæsthetic in preference to the more dangerous agent chloroform.

It is my hope that the Report now in hand, and which at the request of the Committee is, this year, on the Methyl compounds, will not prove of less service.

RESEARCH ON THE METHYLS.

The methyl series of organic compounds are already known in physiological science through one or two of their representatives, direct or substituted. Thus we have in the series the hydride of methyl, or marsh-gas, or firedamp, which, as a cause of death, has been generally studied, and which, indeed, has not escaped the intelligent observation of Mr. Nunneley, of Leeds, as an anæsthetic agent. Then, again, as substitution-products of this series, we have the well-known agent chloroform, the terchloride of formyle; and lastly, we have a substance concerning which there has been considerable discussion of late, the tetrachloride of carbon, also an anæsthetic.

Before I go further, and that all may be carried with me, let me briefly

state what compounds of the methyl series are about to engage our attention, and what is their nature and derivation.

The most common methyl-compound, that, in fact, which came first to the use of the world at large, is what is called methyl-alcohol or wood-spirit-naphtha,—a substance which comes over in combination with water during the dry distillation of wood. Chemically considered, this and all the other bodies of the series are constructed on a radical called methyl. This radical, which has only been isolated by one or two observers, exists as a permanent gas. Its composition, according to the new formula, is CH_3.

From this radical we have handed to us by the chemist two sets of compounds. In one set we have the radical acting as a base, producing by combination with other elements bodies which may be taken as the analogues of salts. In the second set we have the carbon continuing steady, but the hydrogen replaced by some other element. For convenience sake, I will place such compounds as I have studied physiologically in two groups, as follows:—

GROUP (A).

Methylic alcohol	$\left.\begin{matrix} CH_3 \\ H \end{matrix}\right\} O.$
Hydride of methyl / Marsh-gas—firedamp	$CH_3H.$
Chloride of methyl	$CH_3Cl.$
Iodide of methyl	$CH_3I.$
Bromide of methyl	$CH_3Br.$
Acetate of methyl	$\left.\begin{Bmatrix} CH_3O \\ CH_3 \end{Bmatrix}\right. O.$
Methylic ether	$\left.\begin{Bmatrix} CH_3 \\ CH_3 \end{Bmatrix}\right. O.$
Nitrite of methyl	$CH_3, NO_2.$
Nitrate of methyl	$\left.\begin{Bmatrix} CH_3 \\ NO_2 \end{Bmatrix}\right. O.$

GROUP (B).

Chloroform	$CHCl_3.$
Tetrachloride of carbon	$CCl_4.$
Bichloride of methylene	$CH_2Cl_2.$

PHYSIOLOGICAL ACTION OF METHYLIC ALCOHOL.

The methylic alcohol used was the pure alcohol. It is a colourless spirit, its specific gravity 0·810, its boiling-point 140° Fahr. The physiological action may be obtained either by direct administration with water, or by inhalation of the vapour. When the methylic alcohol is thus administered so as to produce distinct effects, the first symptoms are those of excitement followed by languor. These symptoms are succeeded by laboured breathing, and soon by gaspings, and by deep sighs which occur at intervals of about four seconds. There is evidenced upon this, want of power in the limbs with rolling movements on the side and complete intoxication. From this time, if the dose of the alcohol is continued, the animal lapses into utter prostration, and the breathing becomes blowing, with what is technically called bronchial rale, due to the passage of air through fluid in the finer bronchial passages. Throughout all these stages of intoxication there is imperfect

anæsthesia, and, up to what would seem the extremity of living action, some evidence of sensibility—reflex—is shown when irritation is applied. Brought to the lowest state of prostration by methylic alcohol, an animal will always recover slowly in a warm atmosphere; the period required for recovery being from four to six hours at 65° F. During recovery there are no active convulsive movements, and tremors are not marked symptoms.

When the intoxication arising from methylic alcohol is carried to the extent of destroying life, the respiration and circulation cease almost simultaneously. The lungs are left with a fair amount of blood, and both sides of the heart contain blood. The brain is much engorged with blood, and all the vascular organs are in the same state. The blood is not objectively changed in character. At first, during the state of excitement, it gives to the external vascular parts a marked redness; but as the symptoms are more permanent on the one side, or as recovery is pronounced on the other side, this passes away. The coagulation of blood is somewhat prolonged, but is not prevented.

The evidence, on the whole, is to the effect that methylic alcohol influences principally the motor centres of the nervous system. At all events these centres are prominently influenced, and it is probably only when they begin to fail that the centres of consciousness and sensation succumb. In this respect the methylic, the ethylic, and the amylic alcohols have a common action. But on comparing the effects generally of methylic alcohol with those of amylic and of ethylic or common alcohol, I find the methylic much less potent. It produces prostration and muscular paralysis more quickly, but from that prostration recovery is far more rapid. I showed, previously, in regard to *amylic* alcohol that when the loss of power of the animal under its influence is complete a peculiar symptom is developed, viz. a universal tremor, accompanied with a very deep inspiration. There is no spasm, no pain, no rigidity, but, in medical language, rigors of an intense kind. These rigors are soon established in regular rhythm, and by maintaining the experiment cautiously, they may be kept up for several hours. I have seen them for one hour at the rate of sixteen in a minute as regularly as possible, and by reduction of the agent have lowered them to twelve, eight, and four per minute. All through the breathing is tranquil and the action of the heart good. The rigor occurs spontaneously in this manner, but it can be excited at any moment by touching the animal or blowing upon it, or even by a sharp noise, such as the snap of the finger. When the animal is reduced to entire insensibility, if it be laid in the open air it begins to recover its sensibility at once, but the power to move is suspended for two or three hours, and the rigors also continue, but with decreasing force and frequency. Ultimately the animal recovers thoroughly, and is always very eager for food. When these urgent and, as they would seem, extreme symptoms are carried to their full extent, even an experienced observer would think that recovery were impossible; but in truth the animal cannot be killed by any fair play with amylic alcohol. In order actually to kill, it is necessary to complicate the experiment by actual reduction of air, or by closing the chamber and retaining the carbonic acid of the breath. I showed again, in regard to *ethylic* alcohol, that in a minor degree these same symptoms were developed. In poisoning by *methylic* alcohol these symptoms are nearly altogether absent. The recovery is not only rapid, but easy, approaching, in fact, recovery from the inhalation of ether.

I notice specially this difference of action of the three analogous alcohols

for two reasons; first, because the fact is an exposition of a general physiological law in relation to bodies of the same series; and secondly, because there is a practical lesson behind bearing upon the employment of these substances. The physiological law is this, that the period of time required by these bodies to produce their effects, and the period of time required for recovery, turns altogether on the evaporating-point of the fluid used. This is so certain that when in an analogous series of fluids the action of one of the series is well learned, the action of the others may be safely predicted from the boiling-point. In illustration, here are these three alcohols—amylic alcohol, ethylic alcohol, and methylic; the first boils at 270° Fahr., the second at 174°, the third at 140°. If we intoxicate three animals of the same kind with these alcohols, carrying the symptoms in each case to the same degree, and then leave the animals to recover in the same temperature, say 60°,—then if the animal in the methylic alcohol be four hours recovering, the one in ethylic alcohol will be seven hours, and the one in amylic will be sixteen hours.

The explanation of this fact is very simple, and reduces the phenomenon to a question, I had almost said, of mechanical force. The alcohols taken into the body enter into no combination which changes their composition. They pass out of the body chemically as they entered it, and their evolution and the time of their evolution is a mere matter of so much expenditure of force (caloric) to raise them and carry them off. To test this more directly, intoxicated animals were placed in different degrees of temperature with the unerring result of a quickened recovery in the higher degrees.

The practical lessons I would refer to are two in number. I would suggest that in all cases of alcoholic poisoning in the human subject, the most important condition for recovery is a high temperature. The use of the hot-air bath raised to 150° or even 180° would be the most perfect means of recovery. Next I would point out that as methylic alcohol is much more rapid in its action, and much less prolonged in its effects than is common alcohol, it would be used with great advantage by the physiological physician in all cases where he feels a demand for an alcoholic that shall act instantly, and with the least possible ultimate expenditure of animal force for its elimination. It must be observed that in the end all these alcoholic bodies are depressants, and although at first, by their calling vigorously into play the natural force, they seem to excite, and are therefore called stimulants; they themselves supply no force at any time, but take up force, by which means they get away and therewith lead to exhaustion and paralysis of power. In other words, the calorific force which should be expended on the nutrition and sensation of the body is expended on the alcohol.

I have only to add to this recommendation of methylic alcohol as a medicine in substitution for common alcohol, that the methylic spirit when quite pure is extremely palatable, that it mixes easily with water, hot or cold, and that it makes excellent toddy in the proportion of half an ounce to half a pint of hot water. In a conversation I had a few days ago with one of those veterans in physic, who links the medicine of the last generation with the present, he told me that the most celebrated physician and scholar of his acquaintance having once tasted wood-spirit took to it as a drink, and liked it so much better than any other stimulant that he held to it to the last, to the long term of well nigh ninety years.

The Hydride of Methyl.

The hydride of methyl occurs naturally in the form of firedamp in mines, and marsh-gas on land. It is made artifically by heating together in a strong flask acetate of soda, caustic potash, and well-dried lime. For physiological experiment the hydride of methyl can only be administered by inhalation. It is a pleasant gas to inhale, producing no irritation, nor yet giving rise to any of those feelings of excitement which are induced by nitrous oxide gas, or the vapour of chloroform.

As the gas is often a cause of death in mines, I thought it was worth inquiring what percentage of it would prove fatal in the air. I therefore had constructed a glass chamber through which an atmosphere charged with known quantities of the gas could be passed. To my surprise I found that even pigeons, animals peculiarly susceptible to the influence of narcotic gases, could live in an air charged with not less than 35 per cent. of the gas for the space of half an hour, while I could myself inhale the air coming from their chamber without anxiety.

When by pushing the inhalation further death is induced, it is as a very gentle sleep, so gentle indeed that it is difficult to say when the action either of the circulation or of the respiration is over. The lungs are left with blood in them, the heart has blood on both sides, and the blood itself retains its natural character. The death is by the slow negation of breathing. We may gather from these facts many important lessons in regard to the risks and dangers of miners from firedamp. I should think it is almost impossible that any body of men, or any men who were awake in a mine, could be so entrapped with firedamp only as to die in the absence of an explosion. In accidents where this seems to have occurred, I should imagine that with the firedamp there is also evolved carbonic acid gas. I can, however, imagine after an explosion, when the mine becomes for a moment a great vacuum, that there would be sufficient entrance of the gas to produce a fatal atmosphere. In such case death would be prolonged, but as easy as sleep; two truths, which in cases of accident should inspire thankfulness and hope—thankfulness that those who thus die for us suffer little, hope as to the possibility of rescue which should not for days be abandoned. The best direct means of recovery of those under the influence of firedamp is exposure to heated air, with the administration of warm nourishing drinks, such as milk. Alcoholics do decided harm.

[From this point the author proceeded at length with the descriptions of the actions of chloride of methyl, the iodide, bromide, and acetate, methylic ether, nitrite of methyl, and the nitrate, which we must very briefly record, and pass to his researches on chloroform and its allies.]

Chloride of Methyl.

The chloride of methyl made by the direct action of hydrochloric acid on methylic alcohol can only be conveniently used for physiological purposes, as a gas, or as a gas saturating ether. It must therefore be administered by inhalation to see its full effect. I took some of it by the mouth in solution with ether, but the heat of the mouth prevented me from swallowing it perfectly. Inhaled with atmospheric air, in the proportion of 15 per cent. it produces in all animals good anæsthesia, without excitement and with excellent recovery. Carried to the extent of causing death, the action of the heart outlives the respiration; the lungs are left with blood in the pulmonic

circuit, and both sides of the heart are filled with blood which is little changed in colour. The muscles retain their irritability after death, and are capable of response to galvanism for two and even three hours after death, while the heart will continue to pulsate spontaneously for half an hour or even forty minutes.

Iodide of Methyl.

The iodide of methyl that was used was made, in the usual way, by distilling wood-spirit with iodine and phosphorus; viz. 12 of spirit with 8 of iodine, and 1 of phosphorus. The fluid at first was nearly colourless, and boiled at 108° Fahr., its sp. gr. being 2·199. Although kept well excluded from the light it underwent slight change, setting iodine free. It is altogether a very difficult compound to manipulate with, physiologically, in the concentrate form. It can be managed better when diluted with methylic alcohol or with ether. I succeeded, however. to subject animals to the vapour, and discovered that in proportions of 10 per cent. the action of the iodide is the same as that of the chloride, *i. e.* it is a very good anæsthetic. When, however, the iodine is escaping there is profuse lachrymation and salivation. There is also free secretion from the bronchial surface, and one animal died from this accidental bronchitis some hours after it had recovered from the anæsthesia.

Bromide of Methyl.

The bromide of methyl, the analogue of the chloride and iodide, bromine taking the place of chlorine or iodine, is a substance having a specific gravity of 1·660, and a boiling-point of 55° F. I used it in experiment by inhalation alone, and also in combination with ether in equal parts. It was discovered as good an anæsthetic as the chloride, and recovery was perfect; but there was some degree of irritation and salivation excited, results probably due to free bromine. The irritation is produced chiefly in the eyes and in the salivary glands, causing lachrymation and salivation.

Acetate of Methyl.

The acetate of methyl obtained by distilling acetate of soda, oil of vitriol, and methylic alcohol, with rectification over lime and chloride of calcium, is a clear fluid with an agreeable odour. Its specific gravity is ·910, and its boiling-point 136° Fahr. It is administered easily by inhalation, and in four minutes, in the proportion of 9 per cent., it produces gentle sleep with quick recovery if the administration be short. Prolonged inhalation causes difficult breathing. It is a substance which admits of being largely used in medicine, in cases where a diaphoretic and narcotic are required in combination.

Methylic Ether.

This substance, obtained by the action of sulphuric acid on methylic alcohol, is a gas at ordinary temperatures, and does not admit of being used physiologically in any other state. It has an agreeable odour, and is taken up easily by ether. I used it most conveniently with ether, liberating it by heat below the boiling-point of the ether. Administered by inhalation it produced perfect anæsthesia, and that in an easy and rapid manner. The breathing is scarcely disturbed, and the action of the heart is extremely regular. Recovery is not very rapid, but perfect.

Nitrite and Nitrate of Methyl.

The nitrite and the nitrate of methyl possess an action so much in common that I may take them together. The nitrite made by the action of nitrous acid on methylic alcohol is most conveniently used with ether. The nitrate made by distilling the wood-spirit with nitrate of potash and sulphuric acid can be used directly. It is a heavy liquid, having a specific gravity of 1·180 and a boiling-point of 140° Fahr.

As with the nitrites of amyl and ethyl, the action of these substances is to produce intense excitement and rapid action of the heart and arteries. The action, however, is not so vehement as from nitrite of amyl, and a longer inhalation is required before the excitement is perceived. In the human subject the face becomes red, the vessels of the head seem full and distended, and the pulse is readily brought up to 120 and even 130. On the inferior animals the same excitement is manifested, and death is preceded by convulsive jerks. After death the lungs are found collapsed and white, and the heart flaccid and full of blood on both sides. On exposure to the air the heart recommences to contract, and continues its contractions for long periods, in one case (a rabbit being the subject) for forty minutes. The blood in the blood-vessels remains fluid for an hour or more, but coagulates readily on exposure to a warm air. The muscles throughout the whole of the body are flaccid, but will contract, for periods of one and two hours after death, under the influence of the galvanic current. Neither nitrite nor nitrate of methyl produce true anæsthesia.

Of the two substances the nitrate of methyl is most conveniently used, and as it possesses all the physiological properties of nitrite of amyl with less energy, it would, I think, be the best agent in medicine. Its power in producing muscular relaxation is most marked and general, and its employment in cases of a desperate spasmodic character, as in tetanus, would be a rational scientific procedure.

I now come to the second group of substances to which I have directed attention; viz., chloroform, tetrachloride of carbon, and bichloride of methylene.

Chloroform.

Chloroform made by the action of bleaching-powder on methylic alcohol, or ethylic alcohol, is a substance so well known as an anæsthetic that I shall dwell but very briefly upon it. It has a specific gravity of 1·495, and it boils at 142° Fahr. From the large number of experiments I have made with this substance to determine its mode of action, and the manner in which it sometimes destroys life, I am led to the conclusion that its first influence is always exerted on the centres of motion of the nervous system with an extension of that action to the centres of volition and sensation. I agree with Dr. Snow in tracing out four distinct stages in its action, one of gentle excitement of the circulation, a second of exalted action of the motor centres, a third of depression of motion with destruction of consciousness, and a fourth of complete paralysis of motion and sensation. I have also been led slowly to the conviction that the cause of death from chloroform is in every case due to arrest of nervous function, and that the idea of any direct action of the agent on the muscular structure of the heart is without foundation. In eighty-seven experiments conducted specially to determine the direct influence of chloroform on the heart, I found in every case that organ capable of reaction on its

exposure to the air, and the lungs always bloodless, white, and collapsed; I found, in fact, precisely the same state of things as occurs when the medulla oblongata is rendered inactive by extreme cold. The mean period of time during which the muscles respond to galvanism after death by chloroform varies from twenty minutes to half an hour. The coagulation of the blood is natural.

The advantages of chloroform over other anæsthetics, so far known, are its readiness of application, and the prolonged action of the anæsthesia induced. Its main disadvantage lies in its high boiling-point, and the consequent amount of force required to eliminate it from the body. Indeed, according to my experience it is never eliminated purely by the lungs, but by all the excreting organs, so that any error or deficiency in those organs may lead to such suppression of elimination that the nervous centres may become overwhelmed, with consequent arrest of their activity. The temperature of the air exerts a marked influence on the effects of chloroform in this respect of elimination; the influence of the anæsthetic being greatly prolonged when the air is loaded with moisture and the thermometer is low. The best means of restoration in impending death from chloroform is the introduction into the lungs by artificial respiration of air heated to 130° Fahr. Under this influence, in animals even with the chest laid open, the heart is seen to leap into instant activity and the arteries to recommence pulsation. In one experiment this restoration of vascular motion was so distinct that the blood made its way round the arterial circuit, the nervous centres regained power, and the animal (a dog) may be said temporarily to have lived again.

To fill the lungs with warm air for the purpose described, a small pair of handbellows connected with a tube of thin metal, in a coil, answers well. With a spirit lamp the coil can be almost instantly made hot, and the air passing through it with brisk force can easily be raised to 130° Fahr. It is only necessary to inject the air through one nostril.

Tetrachloride of Carbon.

Recently, the substance known as $C\,Cl_4$—the tetrachloride of carbon—has been brought into use as a substitute for chloroform. In this body all the hydrogen elements of marsh-gas are substituted by chlorine, and it is indeed the final result of the action of chlorine on that gas. It is a fluid of not very pleasant odour; its boiling-point is 172° Fahr., its specific gravity is 1·600. As this substance is now gaining importance, I have thought it proper to subject it to very careful experiment, and I feel it my duty to state, both on theoretical and practical grounds, that it is more dangerous than chloroform, and if it were as generally used it would act fatally in a much larger number of cases. In its action it presents the same four stages as chloroform, but the second stage is more prolonged and intensified. In one animal (a rabbit) tetanic convulsion of an extreme character was presented during this stage. But the worst feature in the administration of this body is the slowness of its elimination, a slowness fully accounted for by the boiling-point. Saturating the nervous centres, and expending their force to the fullest, it kills far more quickly and determinately than chloroform, and so completely is motion paralyzed that the muscles scarcely respond to galvanism five minutes after dissolution. In order to make an exact comparison (and it is from this comparison I draw the results arrived at), I placed animals of the same kind, at the same time, at the same tem-

perature in chambers of the same size, and administered the same doses of chloroform and of the tetrachloride of carbon. Pigeons and rabbits alike gave evidence of the more severe effects of the latter substance. In this opinion my friend Dr. Sedgwick, who has rendered me the most valued aid in these inquiries, entirely coincides.

The Bichloride of Methylene.

The last compound on our list is of great interest, from the circumstance that it promises to be a new and valuable anæsthetic. In experimenting with chloride of methyl in ether, I was so struck with its good action that I asked Mr. Robbins, the chemist who has prepared the compounds for me, to endeavour to find a more stable compound, having similar physical properties, from the methyl series. In a few days he brought me the fluid I now place before the Section, made for him by Dr. Versman. This fluid is the bichloride of methylene. It is formed by the action of nascent hydrogen on chloroform, and it differs from chloroform in that one atom of chlorine is replaced by an atom of hydrogen. Its boiling-point is 88° Fahr, and the odour of its vapour is sweet and much like that of chloroform. On testing it physiologically I found it to be a gentle and perfect general anæsthetic. Under its influence animals lapse into the third stage of anæsthesia, with the slightest exhibiton of the stage of excitement. The insensibility is deep and well sustained, and the recovery quiet and good. [Dr. Richardson here showed an experiment of putting a pigeon into a deep sleep.] In some experiments, in order to see the extreme effect, I have carried the administration to the extent of arresting the phenomena of life. I have thus learned that the respiration and circulation, under the last action of this agent, cease simultaneously, and that the muscles retain their irritability for even an hour after death. The lungs are left with blood in the respiratory circuit, both sides of the heart are charged with blood, and the blood itself remains unaltered in physical property. Compared with other anæsthetics, the bichloride of methylene appears to me to combine the anæsthetic power of chloroform with the safer properties of ether. It is too early to speak positively on this point, but if the expectation be fulfilled, the perfection of a general anæsthetic will have been obtained for the benefit of the world. And, even should this happy result not be accomplished, the way at least is paved towards the discovery of some intermediate body which shall answer to the required physical demand.

In reviewing all the facts connected with the physiological action of the methyl series, we gather that, according to their composition, they exert certain definite influences on different parts of the nervous organism. The oxide produces an influence of its own, that of slowly paralyzing the motor function before destroying common sensibility. The nitrite and nitrate rapidly paralyze the centres of motion; while the chloride, the iodide, and the bromide, together with the substitution chlorine compounds, not only paralyze motion but also destroy sensation. I conclude this Report with one other observation. At first sight it may seem that the isolation of the phenomena produced by special agents, and the discovery of a new anæsthetic are sufficient characteristics of this research. With every respect, I submit that a broader question is involved. At the Meeting at Birmingham I suggested, almost with a feeling of fear, that out of these studies might spring up a fixed principle of therapeutical discovery. Now I have the conscious happiness of

knowing that the hypothesis was correct. I feel convinced, on this longer experience, that by continued labour we shall be able to pronounce the precise physiological meaning and value of all the organic compounds, to extend the knowledge of the curative action of these compounds to every condition of disease that is physically remediable, and to bring therapeutics into the position of a positive science.

POSTSCRIPT.

While these Transactions have been in preparation the opportunity has been afforded me of testing the action of bichloride of methylene as a general anæsthetic on the human subject, and with the happiest results. On October 15th of last year (1867), having first inhaled the vapour myself to complete anæsthesia, I afterwards administered it to a lady while Mr. Spencer Wells performed one of the formidable operations in surgery. Not one unfavourable symptom resulted, and since then the bichloride of methylene has been in frequent use in surgery. Up to the present time (January 20, 1868) no untoward event has followed its administration.—B. W. R.

Preliminary Report of the Committee for the Exploration of the Plant Beds of North Greenland, appointed at the Nottingham Meeting, 1866.

MR. WHYMPER, one of the Members of the Committee, having made arrangements for visiting Greenland, a meeting of the Committee was held on the 4th of April, in London, and it was there resolved that the sum of £100 voted by the British Association for the purposes of this exploration be handed to Mr. Whymper, on his giving a written undertaking to fulfil the conditions laid down by the Association, as far as lay in his power.

In addition to this grant, Mr. Whymper was further assisted by a grant of £200 from the Government Grant Committee of the Royal Society.

Mr. Whymper started from Copenhagen about the 20th of April, taking with him as assistant Dr. Robert Brown, a gentleman already well known for his explorations in North-west America, especially as to the Natural History of British Columbia.

Since the expedition left Copenhagen, no intelligence from it has been received by this Committee.

The description of the plant remains from North Greenland which have been already brought to these countries has been completed by Prof. Oswald Heer of Zurich, and his work on the 'Fossil Flora of the Polar Regions' is now nearly printed, and will be published in a short time.

ROBERT H. SCOTT, *Sec.*

Report of a Committee, consisting of Mr. J. Scott Russell, Mr. T. Hawksley, Mr. J. R. Napier, Mr. William Fairbairn, *and* Professor W. J. M. Rankine, *appointed to analyze and condense the information contained in the Reports of the "Steam-ship Performance" Committee and other sources of information on the same subject.*

At the Nottingham Meeting of the British Association in 1866, the following recommendation was passed,—"That Mr. J. Scott Russell, Mr. T. Hawksley, Mr. James R. Napier, Mr. William Fairbairn, and Professor W. J. Macquorn Rankine be a Committee to analyze and condense the information contained in the Reports of the Steam-Ship Performance Committee, and other sources of information on the same subject, with power to employ paid calculators or assistants, if necessary; and that the sum of £100 be placed at their disposal for that purpose."

The Committee so appointed employed as a calculator and assistant Mr. John Quant, Naval Architect, who has discharged the duties entrusted to him with great industry and ability.

The whole of the sum of £100 has been expended.

The contents of the present Report are arranged as follows:—

Catalogue of Tables as published in the years 1857, 1858, 1859, 1860, 1861, 1862.

Method of condensation.

Table I. Condensed Table of Merchant Paddle Steamers.

Table II. Condensed Table of Merchant Screw Steamers.

Tables III., IV., V., and VI. Condensed Tables of Men-of-War, forming four groups.

Catalogue of Tables as published in the years 1857–62.

"1857, Appendix A.—Tabular comparison, the old, the present, and proposed measurement for tonnage; an analysis of ships and steamers, their proportions, displacement, weight, and resistance; engines and steam-power, and result of speed realized."

This Table is of little or no use for analyzation, for this reason—that of the few steamers of which the displacement and speed are given, no indicated horse-power has been returned, and *vice versâ*. Some of the vessels contained in it are mentioned in the condensed Tables; but their quantities are given as taken from other Tables.

"Table A.—Summary of returns, showing the performance of the Chester and Holyhead Company's steam-vessels 'Anglia,' 'Cambria,' and 'Scotia,' and the consumption of coal between Holyhead and Kingstown, under certain conditions taken at standard tests."

"1858, Appendix II.—Table showing the difference which exists between the 'register tonnage' of vessels and the 'tons weight' of cargo actually carried in the trade and navigation of the United Kingdom with foreign countries and British possessions in 1852, 1853, 1854, and 1855, deduced from returns of the Board of Trade."

"1859, Appendix V., Table I.—Return of the performance of the Chester and Holyhead Company's steam-vessels, under trial for a standard test."

"Appendix V., Table II.—Copy of a return laid before a Select Committee of

the House of Commons. See Blue Book on Dublin and Holyhead Mail Service, 1853, Appendix, p. 176. A return of the speed and consumption of fuel of the steamboats under regulated conditions of time, pressure, and expansion, for the undermentioned periods."

"Appendix V., Table III.—Chester and Holyhead Railway, Steamboat Department, 1857. A return of the speed and consumption of coal, under regulated conditions of time, pressure, and expansion, for the undermentioned period (namely, three months, from January 1 to March 31, 1857)."

"Appendix V., Table IV.—Chester and Holyhead Railway, Steamboat Department. A return of the speed and consumption of coal of the steamboats, under regulated conditions of time, pressure, and expansion, for the undermentioned period (namely, from April 1 to June 30, 1857)."

"Appendix V., Table V.—Chester and Holyhead Railway, Steamboat Department. A return of the speed and consumption of coal of the steamboats, under regulated conditions of time, pressure, and expansion, for the undermentioned period (namely, from July 1 to September 30, 1857)."

"Appendix V., Table VI.—A return of the speed and consumption of coal of the steamboats, under regulated conditions of time, pressure, and expansion, for the undermentioned period (namely, from October 1 to December 31, 1857)."

"Appendix V., Table VII.—Chester and Holyhead Railway, Steamboat Department. A return of the speed and consumption of coal of the steamboats, under regulated conditions of time, pressure, and expansion, for the undermentioned period (namely, from January 1 to March 31, 1858)."

"Appendix V., Table VIII.—Chester and Holyhead Railway, Steamboat Department. A return of the speed and consumption of coal of the express and cargo boats, under regulated conditions of time, pressure, and expansion, for the undermentioned period (namely, from April 1 to June 30, 1858)."

"Appendix V., Table IX.—Chester and Holyhead Railway, Steamboat Department. A return of the speed and consumption of coal of the express and cargo boats, under regulated conditions of time, pressure, and expansion, for the undermentioned period (namely, from July 1 to September 30, 1858)."

"Appendix V., Table X.—Chester and Holyhead Railway, Steamboat Department. A return of the speed and consumption of coal of the express and cargo boats, under regulated conditions of time, pressure, and expansion, for the undermentioned period (namely, from October 1 to December 31, 1858)."

"Appendix V., Table XI.—Chester and Holyhead Railway, Steamboat Department. Consumption of coal for the six months ending June 30, 1858."

"Appendix V., Table XII.—Chester and Holyhead Railway, Steamboat Department. Consumption of coal for the six months ending June 30, 1858."

"Appendix V., Table XIII.—A return showing the number of years run before the 'Anglia,' 'Cambria,' 'Scotia,' and 'Hibernia' had new boilers; number of miles run, and consumption of coal per mile, with and without raising steam, banking fires, lying at Kingstown and Holyhead; steam-pressure in boilers."

"Appendix V., Table XIV.—Chester and Holyhead Railway, Steamboat Department. A return of passages made by the steamboats in 3½ hours," &c.

"Appendix V., Table XV.—Chester and Holyhead Railway, Steamboat Department. Mileage run, and expenses per mile, of the passenger boats in the years 1849 and 1856, 1857, 1858."

"Appendix VII., Table I.—Result of experiments with the yacht 'Undine,' July 6, 1858, on the measured mile at Greenhithe."

"Appendix VII., Table II.—Result of experiments with the yacht 'Undine,' July 29 and 30, 1858."

"Appendix VII., Table III.—Result of experiments with the yacht 'Undine,' October 26, 27, and 28, 1858."

"Appendix VII., Table IV.—Experiments with the yacht 'Erminia,' 12th October 1858, in Stokes Bay."

This Table does not give indicated horse-power nor displacement.

"1860. Appendix I., Table I.—Table showing the results of performances at sea and on the measured mile, of seventeen vessels of the Royal Navy, of twenty-two

vessels in the Merchant Service, and of two vessels of the United States Navy; together with the particulars of their machinery."

This Table contains data of the Chester and Holyhead Railway boats, as mentioned in former Reports; the quantities given in it have therefore been selected for the present Report. But in taking the dimensions of the ships, former printed Tables have been compared with this in order to ensure accuracy.

"Appendix I., Table II.—Results of performances of the steamships in the service of the 'Messageries Impériales' of France during the year 1858."

No dimensions of these ships have been given; they have therefore been left out of the present Report.

"Appendix II., Table I.—Chester and Holyhead Railway, Steamboat Department. A return of the speed and consumption of coal of the express and cargo boats, under regulated conditions of time, pressure, and expansion, for the undermentioned period (namely, from January 1 to December 31, 1859)."

"Appendix II., Table II.—Chester and Holyhead Railway, Steamboat Department. Chester and Holyhead steamboat's consumption of coal for the six months ending 30th June 1859."

Appendix II., Table III.—Chester and Holyhead Railway, Steamboat Department. Chester and Holyhead steamboats' consumption of coal for the six months ending 31st December 1859."

These three Tables show the performance of eight ships, the 'Anglia,' 'Cambria,' 'Scotia,' 'Telegraph,' 'Hibernia,' 'Hercules,' 'Ocean,' 'Sea Nymph.'

"Appendix IV.—Table showing the ratios between the indicated horse-power and the grate, the tube, the other heating and total heating-surfaces, and the indicated horse-power; also between the grate- and heating-surfaces and between the indicated horse-power and the coal consumed."

This Table contains two ships of the United States Navy, the same as have been mentioned in Appendix I., Table I.: nineteen vessels of the Royal Navy, whose quantities also are mentioned in other Tables: and nineteen vessels of the Merchant Service, amongst which are the 'Anglia,' 'Cambria,' 'Scotia,' and 'Telegraph.'

"Appendix V.—Description of the hull, engines, and boilers of the United States sloop 'Wyoming.' Table I. Performance of United States steam-sloop 'Wyoming' under steam alone. Table II. Performance of United States steam-sloop 'Wyoming' under steam and sail."

"Supplementary Appendix.—Table showing the trial performance of the steam-vessels 'Lima' and 'Bogota' when fitted with single-cylinder engines, and after being refitted with double-cylinder engines. Also the sea performances of the same vessels under both these conditions of machinery, and on the same service."

This Table has also been embodied in Table II. of printed Report, 1861.

"1861. Table I.—Return of performance of Her Majesty's vessels, furnished by the Admiralty."

"Table II.—Showing the results of the performance of six of Her Majesty's vessels under various circumstances."

"Table III.—Performance of Her Majesty's Ship 'Victor Emmanuel' at sea."

"Table IV.—Return of seven trials on the measured mile in Stokes Bay of Her Majesty's Ship 'Victor Emmanuel.'"

"Table V.—Return showing the results of performance of eighteen vessels in the Merchant Service under various conditions."

"Table VI.—Chester and Holyhead Railway, Steamboat Department. A return of the speed and consumption of coal of the express and cargo boats, under re-

gulated conditions of time, pressure, and expansion, for the undermentioned period (namely, from the 1st January to 31st March 1860)."

"Table VII.—Chester and Holyhead Railway, Steamboats. Consumption of coal for the twelve months ending December 31, 1860."

"Table VIII.—City of Dublin Steam Packet Company. A return of the average time of passage and consumption of coal of the mail steamers for six months, ending June 30, 1860."

"Table IX.—City of Dublin Steam Packet Company. A return of the average time of passage and consumption of coal of the mail steamers for three months, ending September 30, 1860."

"Table X.—Resultats de la navigation des paquebots des services maritimes des Messageries Impériales pendant l'année 1859."

No dimensions of those ships have been given; and they have therefore been left out of the present Report.

"Table XI.—Resultats de la navigation des paquebots des services maritimes des Messageries Impériales pendant l'année 1860."

Of those ships also no dimensions have been given; and they have therefore been left out of the present Report.

"Appendix, Table XII.—Return of the average passages of mail packets, and consumption of coal for six months, ending 31st March 1861."

"Appendix, Table XIII.—Steamship 'Leinster,' on trial from Holyhead to Kingstown, April 4, 1861."

"Appendix, Tab'e XIV.—Steamship 'Ulster,' on trial from Kingstown to Holyhead, April 5, 1861."

"1862. Table II.—Return of the particulars of the dimensions of twenty vessels in Her Majesty's Navy, with the results of their trials upon completion for service."

"Table III.—Results of the performances at sea, and when on trial, of Her Majesty's ships 'Colossus,' 'St. George,' and 'Arrogant.'"

Of these steamers also no displacement or indicated horse-power has been recorded.

"Table IV.—Results of the trials of Her Majesty's Screw Ships, officially tabulated by the Admiralty in 1850."

"Table V.—Results of the trials of Her Majesty's Screw Ships, officially tabulated by the Admiralty in 1856."

"Table VI.—Results of the trials of Her Majesty's Screw Ships, officially tabulated by the Admiralty in 1861 (being a continuation of Tables IV. and V.). Steam Transport Service, Tables VII., VIII., IX., X., XI., XII., XIII., XIV., XV., and XVI. (the last five Tables being summaries of the Tables VII. to XI.)."

These Tables give the results obtained from vessels employed in transport service during the latter part of the Crimean war, showing the respective values of the several steamships, classified according to the nature of the employment, or the special character of the duties required to be performed; and giving, in addition, the cost of moving each ship 1000 miles, &c.

"Table XVII. (continued).—Royal (West India) Mail Packet Company. St. Thomas to Southampton, distance 3622 miles."

"Table XVII.—Royal (West India) Mail Packet Company. Southampton to St. Thomas, distance 3622 miles."

In these Tables, namely, Table XVII. and Table XVII. (continued), no draught of water is stated. They give the speed of the ship and consumption of coals, under various conditions of the state of the hull, of five steamers, viz., the 'Seine,' 'Tasmanian,' 'Atrato,' 'Shannon,' and 'La Plata.'

"Table XVIII.—Royal (West India) Mail Packet Company. Summary made from the Tables of diagrams from indicator and working of the engines belonging to the various ships included in the return furnished of the performances from South-

ampton to St. Thomas, between June 3, 1861, and June 17, 1862, as given in the preceding Tables.

"Table XVIII A.—Table of diagrams from indicator and working of engines, showing the manner in which the summaries in the above Table are obtained."

In both these Tables dimensions are wanting.

"Table XIX.—Return of particulars of the dimensions of the Peninsular and Oriental Steam Navigation Company's Steamship 'Moultan,' with tabulated statement showing the results of her performance as compared with six other vessels in the same service."

"Table XX.—Table of results of the performances of sixty-eight vessels of the Imperial and Royal Austrian Lloyd's Steamship Company."

No dimensions of ships nor indicated horse-power are given in this Table.

"Table XXI.—Table of experiments with Her Majesty's Gunboat 'Stork.'"

No displacement given.

"Table XXII.—Eight logs of voyages of the 'Great Eastern.'"

Of the eight logs only three are returned with the indicated horse-power; and those are used in the condensed Tables.

"Table XXIII.—Dimensions and abstract of performances of the Pacific Steam Navigation Company's new paddle-wheel steamships 'Peru' and 'Talca.'"

No dimensions of wheels are returned.

"Table XXIV.—Abstract log of, and notes upon, the performances of the African Royal Mail Company's steamship 'M'Gregor Laird.'"

"Table XXV.—Notes on the performance of the North German Lloyd's Company's steamship 'Hansa.'"

"Table XXVI.—Log of the Earl of Durham's sailing yacht 'Beatrix' on her recent Mediterranean voyage."

The Tables published in the Report of the British Association for 1863, and various data as to the performance of steam-vessels which have been obtained from other sources, still remain to be condensed, in the event of the reappointment of this Committee.

Method of Condensation.

The following method of condensation was drawn up by the Committee in order that it might be followed as far as practicable. In some cases the nature of the data rendered deviations from the method in matters of detail unavoidable; but its principles have been adhered to throughout.

1. All results belonging to any special theory, and all quantities calculated approximately by inference, or ascertained otherwise than by direct measurement, to be excluded from the condensed Tables.

2. Vessels for which any of the essential data (marked E in the annexed list) are wanting to be excluded.

3. The remaining vessels to be divided into groups, according to their speed on trial; for example,—

Group 1,	below			7	knots.
" 2,	from	7	to	9	"
" 3,	"	9	"	11	"
" 4,	"	11	"	13	"
" 5,	"	13	"	15	"
" 6,	"	15	"	17	"
" 7,	above 17 knots.				

TABLE I.—MERCHANT PADDLE-STEAMERS.

Groups of a Speed	3. From 9 to 11 knots.	4. Between 11 and 13 knots.		
Subgroups of Displacement	F. Between 2000 and 4000 tons.	D. Between 500 and 1000 tons.		
Name of Vessel	La Plata.	Anglia.	Admiral.	Cambria.
Length on load-water-line, in feet	284	187·83	F=84, M=54, A=72 } 210	197·75
Breadth, in feet	40·5	26·16	32	26·16
Mean draft of water, in feet	19·09	9	7·5	8·87
Area of immersed midship section, sq. ft.	....	186·25	214	201·1
Displacement, in tons of 35 cubic feet	3809	620	820	840
Mean immersed girth, in feet	. ...	.. . ...	31·43	.. ..
Material and state of skin	.. ..	... . . .	Iron painted; clean.	....
ENGINES.				
Description	Side lever.	Doub. cyl.	Double cylinder.	Side lever.
Number of cylinders	2	4	4	2
Diameter of cylinders, in inches	103	·48·5	{76·5, 48·5}	73·5
Length of stroke, in feet	9	4·5	4·25	5
Number of revolutions, per minute	12·31	25	24	23
Nominal horse-power	876	330·52	~	392·10
Indicated horse-power	. ...	816·07	744	995·35
PROPELLER.				
Description	Radial, fixed.	Modif. Morgan's.	Feathering.	Modif. Morgan's.
Diameter, in feet	36	24·5	20·05 to journals.	28
Length of paddle, in feet	10 5	9 5	7	7
Breadth of paddle, in feet	3·16	3·67	3	4
Number of paddles	28	12	11	16
Depth of immersion of lower edge, in feet	. . . .	5·16	. .. ...	5·83
Speed of vessel, in nautical miles per hour	10·79	12·96	12	12·4
BOILERS.				
Description	Tubular.	Tubular.	....	Tubular.
Pressure of steam in boiler, lbs. on the sq. in.	14·82	14	25	14·5
Steam-room, in cubic feet	4240	300	. .. .	....
Water-room in cubic feet	5125	. .....	.. ..	....
Number of furnaces	24	12	... .	12
Number of boilers	4	2	.. . ...	4
Grate surface, in square feet	616	160	100	165
Total heating surface	16947	4508·44	.. ..	6134
Consumption of coals, in lbs. per hour	8149	5580	2206	5760
WEIGHTS.				
Total of engines, in tons	495·5	... ...	210, with boilers.	117
Each wheel	37·5	22	....	23·5
Boilers without water	219	40·97	....	66
Water in boilers	131	35	....	60
Reference to Reports	1860.	1860.	1860.	1860 & 1861.
Information supplied by	Royal Mail Co. log.	Admiral Moorsom.	Prof. Rankine & J. R. Napier.	....
Remarks	Moderate wind and tide.	Fair wind; fair tide; moderate sea.	....	Wind light.

Table I. (*continued.*)

Groups of a Speed	4. Between 11 and 13 knots.							5. Between 13 and 15 knots.		
Subgroups of Displacement	D. Between 500 and 1000 tons.	E. Between 1000 and 2000 tons.						B. Between 125 and 250 tons.	D. Between 500 and 1000 tons.	E. Between 1000 and 2000 tons.
Name of Vessel	Cambria (lengthened).	Callao.	Valparaiso.	Lima.	Lima.	Bogota.	Bogota.	Vulcan.	Scotia.	Telegraph.
Length on load-water-line, in feet	237	232	232	251	251	250	250	{F=80, A=80} 160	192·57	243·8
Breadth, in feet	26·16	29	29	30	30	30	30	16·3	27	28·16
Mean draft of water, in feet	9·31	11·12	11·67	11·5	12·15	11·91	....	4·5	8·83	9·67
Area of immersed midship section, sq. ft.	200·03	280	308	302	321	302	....	56	188·78	224·7
Displacement, in tons of 35 cubic feet	980	1150	1220	1345	....	1410	....	140	680	1173
Mean immersed girth, in feet	....	....	....	....	....	....	....	14·75	....	....
Material and state of skin	....	....	....	....	....	....	....	Iron painted, clean.	....	....
Engines.										
Description	Side lever.	Double cylinder.	Doub. cyl.	Doub. cyl.	Side lever.	Double cylinder.	Side lever.	Oscillating.	Double cylinder.	Side lever.
Number of cylinders	2	4	4	4	2	4	2	2	4	2
Diameter of cylinders, in inches	73·5	{2 of 90, 2 of 52}	{2 of 90, 2 of 52}	{2 of 90, 2 of 52}	73	{2 of 90, 2 of 52}	73	36	52	77·25
Length of stroke, in feet	5	5	5	5	6	5	6	3·5	4·5	5·5
Number of revolutions, per minute	20·25	24	24	24	22·5	23	....	About 50.	24	25
Nominal horse-power	392·10	320	320	320	400	320	400	....	379·92	448
Indicated horse-power	837·34	1050	800	1160	1300	1100	1300	412	934·18	1165·98
Propeller.										
Description	Common.	Feathering.	Feathering.	Feathering.	Ordinary.	Feathering.	Ordinary.	Feathering.	Modif. Morgan's.	Modif. Morgan's.
Diameter, in feet	25	26	26	26	26	26	27·5	12·2 to journals.	24·5	26·83
Length of paddle, in feet	8	8·5	8·33	8·16	8·5	8·5	8·5	6	10	10
Breadth of paddle, in feet	2·16	3·08	3·16	3	2·5	3·08	2·5	2·25	3·67	4
Number of paddles	32	12	10	12	24	12	24	....	12	14
Depth of immersion of lower edge, in feet	3·33	4	3·5	4	....	4	....	....	6	4·42
Speed of vessel, in nautical miles per hour	12·23	12·9	11·53	12	13	12·5	12·75	14·5	13·61	13·23
Boilers.										
Description	Tubular.	Tubular.	Flue.	Tubular, superheated.	Tubular.	Tubular.	Tubular.	....	Tubular.	Tubular.
Pressure of steam in boiler, lbs. on the sq. in.	14	26	22	26	16·5	26	....	....	12	14
Steam-room, in cubic feet	....	1600	390	1600	1450	1600	1450	....	325	406
Water-room, in cubic feet	....	2000	720	2000	2520	2000	2520	....	....	....
Number of furnaces	12	6	6	6	12	6	12	....	12	12
Number of boilers	4	2	2	2	4	2	4	....	2	2
Grate surface, in square feet	450	140	130	136	252	140	252	....	186	166·25
Total heating surface	6893	3340	2530	3336	7655	3340	7652	....	5390·91	8758·01
Consumption of coals, in lbs. per hour	5241	2240	2464	3024	6720	2240	6720	....	6240	7800
Weights.										
Total of engines, in tons	117	220	200	220	220	220	220	....	....	....
Each wheel	11·95	26	25	20	16	26	11	....	23	23
Boilers without water	83	60	34	60	80	60	80	....	47·17	70
Water in boilers	63	40	36	40	70·5	40	70	....	39	65
Reference to Reports	1860 & 1861.	1860 & 1861.	1860.	1860 & 1861.	1860 & 1861.	1860 & 1861.	1860 & 1861.	....	1860.	1860.
Information supplied by	....	Randolph, Elder & Co.	Randolph, Elder & Co.	Randolph, Elder & Co.	....	....	....	Professor Rankine, and Jas. R. Napier.	Admiral Moorsom.	Admiral Moorsom.
Remarks	Moderate breeze; variable tide; comparatively smooth sea.	Light head wind; variable tide; light head sea.	Light wind; alternate tide; no sea.	....	....	Wind abeam; variable tide; short beam sea.	....	....	Light wind; tide partly favourable.	Light wind; tide partly favourable.

Table I. (continued.)

Groups of a Speed	5. Between 13 and 15 knots.								6. Between 15 and 17 knots.	
Subgroup of Displacement	E. Between 1000 and 2000 tons.	F. Between 2000 and 4000 tons.				I. Above 16000 tons.			C. Between 250 and 500 tons.	E. Between 1000 and 2000 tons.
Name of Vessel	Mersey.	Delta.	Atrato.	Shannon.	Paramatta.	Great Eastern.			John Penn.	Leinster and Ulster.
Length on load-water-line, in feet	254·42	308	336·5	330·13	329·42		{F=330, M=120, A=230} 680		171·75	{F=172, A=155} 327
Breadth, in feet	30	35·25	40·92	44	43·75		82·5		18·75	35
Mean draft of water, in feet	10·25	15	16·33	16·96	16·71	23·62	23·71	23·60	6·79	13·37
Area of immersed midship section, sq. ft.	261	400	....	606	606·16	1678	1685·42	1676·35	99	330
Displacement, in tons of 35 cubic feet	1300	2300	3034	3840	3862	20250	20500	20240	280	1815
Mean immersed girth, in feet	....	39·7	....	54·7	....	75·3	75·4	75·3	....	40·24
Material and state of skin	....	....	....	....	....		Iron painted.		....	Iron painted.
Engines.										
Description	Oscillating.	Oscillating.	Side lever.	Side lever.	Double cylinder.		Oscillating.		Oscillating.	Oscillating.
Number of cylinders	2	2	2	2	4		4		2	2
Diameter of cylinders, in inches	60	72	96	97	68·125		74		46	96
Length of stroke, in feet	5	7	9	9	9		14		4·16	7
Number of revolutions, per minute	30·25	25·5	14·8	19·075	17	10·95	10·58	10·49	40	23·5
Nominal horse-power	250	400	800	775	764		1000		150	750
Indicated horse-power	1088	1624	2396·44	2928·5	2940	3600	3411	3411	798	4160
Propeller.										
Description	Feathering.	Feathering.	Feathering.	Feathering.	Feathering.		Radial, fixed floats.		Feathering.	Feathering.
Diameter, in feet	21·33	26	36·5	31·8 to journals.	38·5		56		14·83	33
Length of paddle, in feet	8·5	9·5	12	11	12		13		6·16	12
Breadth of paddle, in feet	3·42	4·5	4·5	4·5	4·5		3		2·92	4
Number of paddles	12	12	15	15	15		30		10	14
Depth of immersion of lower edge, in feet	4	6·25	5·5	5·96	6·67	11·75	11·84	11·77	0·83	6·25
Speed of vessel, in nautical miles per hour	12·288	14·67	13·771	13·898	13·906	14·28	13·40	13·13	15·3	16·28
Boilers.										
Description	Tubular.	Lamb's flue.	2 Multiplying tubes, 2 Sheetwater space.	Tubular.	Tubular.		Tubular.		Tubular.	Tubular.
Pressure of steam in boiler, in lbs.	20	20	16	16	17·5		Average.		22	....
Steam-room, in cubic feet	1125	460	6392	3070	5292		....		....	3500
Water-room, in cubic feet	1620	....	....	5250	6440		....		....	....
Number of furnaces	8	4	24	24	24		40		8	48
Number of boilers	4	4	4	4	4		4		2	8
Grate surface, in square feet	178	....	520	567	594		....		129	870
Total heating surface	5407	....	16894	18456	5407		....		3575	17670
Consumption of coals, in lbs. per hour	....	....	....	....	....	12700	16150	11804	....	22400
Weights.										
Total of engines, in tons	81	95	800	709	291		836		27	710
Each wheel	13	1·45	38	77·5	69		185		8	60
Boilers without water	75	120	....	282	220		....		} 22 {	170
Water in boilers	45	....	....	150	184		....			140
Reference to Reports	1860.	1861.	1860.	1860.	1860.		1862.		1860.	1861.
Information supplied by	Royal Mail Company.	Thames Ship Building Company.	Caird & Co.	R. Napier and Sons.	Royal Mail Company.		J. Scott Russell, and results of three logs.		John Penn and Son.	James Watt and Company.
Remarks	Wind No. 4; ebb tide; smooth sea.	Wind light, S.W.	Confused tide.	....	Wind variable; tide and sea moderate.		....		Wind No. 8; flood tide.	Against tide; calm sea.

Table II.—Merchant Screw-Steamers.

Groups of a Speed	3. Between 9 and 11 knots.						4. Between 11 and 13 knots.	
Subgroups of Displacement	A. Under 125 tons.		C. Between 250 and 500 tons.		F. Between 2000 and 4000 tons.		C. Between 250 and 500 tons.	
Name of Vessel	Midge.	Penelope.	Undine.	Lancefield.	Macgregor Laird.	Candia.	San Carlos.	Leonidas.
Length on load-water-line, in feet	58·75	74·33	{FB=70, AB=50} 125	{F=62, M=8, A=75} 145	245	281	192	203
Breadth (extreme), in feet	12·67	12·75	25	23	30	38·9	30	29·12
Mean draft of water, in feet	4	4·08	10·16	8	17·16	18·75	11·83	7·75
Area of immersed midship section, sq. ft.	40	32	154·33	157	440	....	260	207
Displacement, in tons of 35 cubic feet	45	46·5	294	359	2035	2520	700	810
Mean immersed girth, in feet	....	....	....	27·64	....	....	....	....
Material and state of skin	....	....	Iron painted.	Iron painted.	....	....	....	....
Engines.								
Description	Inverted.	High pr. inver.	Inverted direct.	Inverted.	Inverted geared.	Trunk.	Double cylinder.	Vert. inv. cyl.
Number of cylinders	1	2	....	2	2	2	4	2
Diameter of cylinders, in inches	16	11·5	24	28	62	70·75	53 and 31.	40
Length of stroke, in feet	1·33	1	1·25	2·5	3·16	4	2·92	2·5
Number of revolutions, per minute	160	....	101·74	84	34·9	....	47·5	78
Nominal horse-power	25	20	50	50	200	450	120	100
Indicated horse-power	100	93	157·09	200	550	1415	500	340
Propeller.								
Description	4	.. ..	....	Gaining pitch.	....	....	....	....
Diameter, in feet	4·67	4·25	7·83	8	....	15·5	10·5	8·83
Pitch, in feet	9	10·5	11·25	16 to 17	....	20	13·33	18
Length in line of shaft	1·5	·67	1·33	....	....	3·33	Variable.	1·83
Number of blades	3	3	....	3	....	2	2	3
Boss, diameter in feet	9·6×1·16	·71	1·25	....	....	2·2	2·5	2
Depth of immersion at bottom	5·24	4·67	9·50	10	....	....	11	8·08
Speed of vessel, in nautical miles per hour	10·53	10·85	9·26	9·6	9·5	29·26	11·75	11·70
Number of revolutions, per minute	160	146	101·74	84	....	36	48	78
Boilers.								
Description	Cyl mult. tub.	Tubular.	Tubular.	Chamb. 2, uprt. water-tubes.	Tubular.	Lamb's patent.	Spiral flue.	Tubular.
Pressure of steam in boiler, in lbs.	60	45	15·8	....	Average.	....	50	....
Steam-room, in cubic feet	70	38·05	456	....	....	....	750	225
Water-room, in cubic feet	140	86·45	....	....	....	....	800	460
Number of furnaces	1	1	4	2	....	16	1	4
Number of boilers	1	1	1	1	2	4	1	2
Grate surface, in square feet	19·8	13·062	45·17	48	96	286	76	70
Total heating surface, in square feet	326·8	311·302	989·17	1278	4200	7922	2276	2274
Consumption of coals, in lbs. per hour	280	336	....	672	....	....	1176	1204
Weights.								
Total of engines, in tons	2·5	2·7	10·3	....	....	....	70	24
Total of boilers, in tons	5·5	3·9	17·75	....	....	....	1·6	1·35
Total of water in boilers	5·75	2·5	6·5	....	....	....	55	23
Propeller	·25	·15	·85	....	....	....	27	21
Reference to Reports	1861.	1861.	1859 & 1860.	1861.	1862.	1861.	1860.	1861.
Information supplied by	T. W. Dudgeon.	Morrison & Co.	Duke of Sutherland and J. Scott Russell.	Professor Rankine, and Jas. R. Napier.	Royal African Mail Co.	George Rennie & Son.	Randolph, Elder & Co.	Morrison & Co.
Remarks	Gale N.E.; heavy head- and beam-sea.	Moderate wind; no sea; with and against tide.	....	Moderate sea; quarter ebb; favourable tide.	....	....	....	Topsail breeze; moderate swell; last of flood, first of ebb.

TABLE II. (*continued.*)

Groups of a Speed	4. Between 11 and 13 knots.				5. Between 13 and 15 knots.			
Subgroups of Displacement	C. Between 250 and 500 tons.		D. Between 500 and 1000 tons.		C. Between 250 and 500 tons.	D. Between 500 and 1000 tons.		I. Above 16000 tons.
Name of Vessel	Guayaquil.	Maurocordato.	Colombo.	Pera.	Thunder.	Ceylon.	Tasmanian.	Great Eastern.
Length on load-water-line, in feet	195	221	313	F=158, A=142 } 300	240	F=140, A=160 } 300	332	F=330, M=120, A=230 } 680
Breadth (extreme), in feet	30	32·75	37·25	42·08	30	41	39	82·5
Mean draft of water, in feet	11·71	15·75	18·25	18·25	14	18·25	19·08	23·62 | 23·71 | 23·60
Area of immersed midship section, sq. ft.	260	444	518	592	342	582	577	1678 | 1685·42 | 1676·35
Displacement, in tons of 35 cubic feet	840	1963	2487	2972	1000	2940	3375	20250 | 20500 | 20240
Mean immersed girth, in feet	....	....	44·5	48·25	....	52·4	... .	75·3 | 75·4 | 75·3
Material and state of skin	....	....	....	Iron painted.	....	....	... .	Iron painted.
ENGINES.								
Description	Double cylinder.	Vert. inv. cyl.	Beam geared.	Trunk.	Vertical dir.	Inv. dir.	Trunk inverted.	Horizontal direct.
Number of cylinders	4	2	2	2	2	2	3	4
Diameter of cylinders, in inches	53 and 31	48	72	70·75	55	72	68	84
Length of stroke, in feet	3	2·5	5·5	4	3	3	3·5	4
Number of revolutions, per minute	50	49	26	32·5	56·5	61·3	52	38·58 | 37·45 | 36·35
Nominal horse-power	120	150	450	4·50	210	450	550	1600
Indicated horse-power	600	545	1528	1414	924	2040	2800	4656 | 4886 | 4886
PROPELLER.								
Description	....	....	....	....	....	....	....	....
Diameter, in feet	10·5	14·75	15	15·5	15	16·5	17·83	24
Pitch, in feet	12	17	18	21	21	24	33·5	44
Length in line of shaft	2·5	2·16	3·61	3·67	4	4	3·75	....
Number of blades	2	3	3	3	2	3	3	4
Boss, diameter in feet	1·67	2·25	....	2·16	2	....	5	.. . . ..
Depth of immersion at bottom	11	15·75	18	....	15·67	.. ..	19·25	.. ..
Speed of vessel, in nautical miles per hour	12	11·19	12·46	12·556	14·5	13·34	14·25	14·28 | 13·40 | 13·13
Number of revolutions, per minute	104	49	78	65	56·5	61·3	52	38·58 | 37·45 | 36·35
BOILERS.								
Description	Patent spiral flue.	Tubular.	Lamb's sheet flue.	Lamb's patent.	Tubular.	Lamb's sheet flue.	Tubular.	Tubular. Average.
Pressure of steam in boiler, in lbs.	52	15	18·25	....	13	20	19	....
Steam-room, in cubic feet	1000	415	2250	....	780	....	3957	....
Water-room, in cubic feet	1200	1165·4	....	....	1714	....	9375	....
Number of furnaces	1	6	16	16	8	20	26	72
Number of boilers	1	2	4	4	2	4	6	6
Grate surface, in square feet	74	111·3	340	327	214·6	450	510	....
Total heating surface, in square feet	2274	3543·4	8992	8839	4796	9450	12058	....
Consumption of coals, in lbs. per hour	1120	2128	4054	....	1456	....	8400	15859 | 16161 | 14186
WEIGHTS.								
Total of engines, in tons	70	51	263	....	96	....	390	500
Total of boilers, in tons	2·3	4·15	8	....	4	7	14	36
Total of water in boilers	30	42	119	....	56	136	201	....
Propeller	25	26·42	101	....	49	64	150	....
Reference to Reports	1861.	1861.	1861.	1861.	1861.	1861.	1860.	1862.
Information supplied by	West India Mail Company.	Morrison & Co.	P. & O. Company.	George Rennie & Son.	J. W. Dudgeon.	Humphreys, Tennant & Co.	A. & J. Inglis.	J. Scott Russell, and logs of G.E.
Remarks	Light wind; heavy sea.	Calm; no sea; tide in favour.	....	Wind strong, S.S.W.	Calm; no sea; 1 mile against tide.	....	Fresh breeze; flood 2 runs; ebb 2 runs.	

Table III.—Men-of-War (Group 1).

Groups of a Speed	1. From 5 to 7 knots.												
Subgroups of Displacement	B. Between 125 and 250 tons.	D. Between 500 and 1000 tons.			E. Between 1000 and 2000 tons.			F. Between 2000 and 4000 tons.					
Name of Vessel	Minx.	Plumper.	Wasp.	Cruiser.	Meteor.	Glatton.	Massachusetts.	Amphion.	Cornwallis.	Hastings.	Blenheim.	Hawke.	Ajax.
Length on waterline, in feet	131·02	140	188·33	160	172·5	172·5	156·25	177	177·08	176·87	181·23	176·08	176
Breadth (extreme), in feet	22·08	27·5	33·83	31·92	43·92	45·20	32	43·16	49·08	48·5	48·5	48·46	48·54
Tonnage, builder's measurement	303	490	970	753	1469	1535	....	1474	1809	1763	1832	1753	1761
Mean draft of water, in feet	4·16	12·58	12	13·41	7·2	8·5	15·67	19	21·37	20·83	21·12	21·37	22·21
Area of immersed midship section, sq. ft.	59	252	302	328	310	379	405	546	736	725	738	757	790
Displacement, in tons of 35 cubic feet	145	679	970	998	1346	1640	1361	2025	2718	2730	2790	2808	3013
Engines.													
Description	H. H. P.	V. o. geared.	V. os.	H. geared.	H. H. P.	H. H. P.	D. Ac.	Hor.	H. Tr. H. P.	H. H. P.	Hor.	H. Tr. H. P.	Hor.
Number of cylinders	2	2	2	2	2	2	2	2	2	2	4	2	4
Diameter of cylinders, in inches	9·18	27	34	28·06	26·01	25·5	24·875	48	=30·02	30	52	=30	55
Length of stroke, in feet	·75	2	2·75	2	2	2	3	4	2·5	2·5	3	2·5	2·5
Number of revolutions, per minute	196	54	58·58	49	139	127	44·39	45	96	78	43	89	521
Weight per sq. in. on safety valve, in lbs.	55	14	11	10	60	62	......	10	60	65	10	50	10
Nominal horse-power	10	60	100	60	150	150	......	300	200	200	450	200	450
Indicated horse-power	36·5	127·3	236·2	123·7	529·6	693·4	162·54	592·2	572·8	597·3	938·4	500	930·6
Propeller.													
Diameter, in feet	4·08	8·69	11	9	6	6·21	10·5	15	12	12	16	12	16
Pitch, in feet	3·56	6·10	13·5	6·67	12·5	14	16	21	9·5	12·29	20	9·5	18·42
Length in line of shaft	·57	1·16	2	1·12	......	2·27	2	2·5	1·57	1·92	3·33	1·57	3·08
Immersion of lower edge, in feet	2·33	6·42	4·75	7·83	4·5	5·16	13·33	......	14·75	14	......	14·08	12·57
Number of revolutions, per minute	196	109·08	58·58	98	139	127	44·39	45	96	78	43	89	52
Speed of ship, in knots per hour	5·441	6·381	6·976	6·295	5·77	4·5	5·616	6·75	5·8	6·702	5·816	6·525	6·83
Speed of propeller, in knots per hour	6·888	6·568	7·801	6·445	17·139	17·539	....	9·321	8·996	9·457	8·483	8·340	9·447
Speed³ × D⅔ ÷ indicated horse-power	......	157·6	140·8	......	......	......	....	......	......	......	......	......	......
Wind	......	No. 3.	No. 4.	Calm.	......	......	Mod. breeze.	......	......	......	......	No. 2.	Light.
Sea	......	......	......	......	......	......	Moderate swell.	......	Smooth water; a little swell.	......	......	......	Smooth.
Remarks	......	......	......	......	......	......	....	Rigged and fully equipped.	......	......	Rigged and partially equipped.	......	......
Reference to Reports	1862.	1862.	1862.	1862.	1862.	1862.	1860.	1862.	1862.	1862.	1862.	1862.	1862.

TABLE IV.—MEN-OF-WAR (GROUP 2).

Groups of a Speed	2. Between 7 and 9 knots.													
Subgroups of Displacement	B. Between 125 and 250 tons.	C. Between 250 and 500 tons.		D. Between 500 and 1000 tons.										
Name of Vessel	Teazer.	Cygnet*.	Swallow.	Ariel.	Wrangler.	Viper.	Torch.	Lynx.	Reynard.	Lyra.	Rifleman.	Pantaloon.	Hornet.	Nimrod.
Length in waterline, in feet	130	145·08	139	139	160	160	145	160	147·67	139	150	151	160	200
Breadth (extreme), in feet	21·79	25·42	27·92	27·92	25·33	25·33	25·33	25·33	27·83	27·83	26·57	29·08	31·87	30·16
Tonnage, builder's measurement	296	428	486	486	477	477	425	477	516	485	486	577	753	851
Mean draft of water, in feet	5·25	9·14	10·25	10·79	10·42	10·46	11·37	10·83	10·92	12·20	11·54	13·08	13·37	10·75
Area of immersed midship section, sq. ft.	82·9	168	180	195	198	199	224	209	222	239	233	263	312	253·5
Displacement, in tons of 35 cubic feet	205	393	455	500	546·5	550	557	586	604	638	678	798	937	969
ENGINES.														
Description	V. os.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor. trunk.	Hor.	Hor.	V. os. geared.	Hor.	Hor.	Hor.
Number of cylinders	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches	27·06	32	25·5	25·5	40·5	40·5	32	=35·1	28	25·5	34	38	38·06	58·06
Length of stroke, in feet	2·5	1·5	1·75	1·75	2	2	1·5	1·67	2	1·75	2·75	2	2	2·25
Number of revolutions, per minute	51·5	82	76·5	82	63·33	66	91·75	80	56	84	35·57	100	78	60·625
Weight per sq. in. on safety-valve, in lbs.	9	21	20	20	20	20	20	20	14	20	10	20	20	20
Nominal horse-power	40	80	60	60	160	160	80	160	60	60	100	150	100	350
Indicated horse-power	128·2	162·6	164·6	190·1	224·6	267·3	280·7	222·1	153·6	227·1	166·5	483·75	411·4	383·1
PROPELLER.														
Diameter, in feet	5	9	9	9	11·08	11	9	11	8·92	9	9	10	10	11
Pitch, in feet	7	12·01	10·87	11	15	15	13·08	9·75	7·25	11	8·42	12	15·46	20·5
Length in line of shaft	1·16	1·97	1·81	1·81	2·52	2·57	2·25	2·42	1·33	1·83	1·45	2·29	1·96	3
Immersion of lower ledge, in feet	....	4·96	5	4·83	4·33	4·57	6·25	4·92	. .	6·33	6 5	6·5	7·08	4·75
Number of revolutions, per minute	192·09	82	76·5	82	63·33	66	91·75	80	112	84	89·64	100	78	60·625
Speed of ship, in knots per hour	7·685	8·677	7·429	7·647	8·012	8·8	8·843	7·033	7·3	7·45	7·15	8·934	8·744	8·818
Speed of propeller, in knots per hour	13·263	9·833	8·206	8·897	9·371	9·765	11·841	7·694	8·009	9·114	7·441	11·837	11·893	12·259
$\text{Speed}^3 \times D^{\frac{2}{3}} \div$ indicated horse-power	....	215·5	147·4	148·2	153·08	171·1	166·8	109·7	....	134·9	....	126·8	155·6	175·3
Wind	....	No. 2.	No. 5.	....	....	Light breeze.	No. 3 to No. 4.	No. 4.	....	....	....	No. 3.	No. 2.	No. 3 to No. 4.
Sea	....	....	....	....	....	....	....	Moderate swell.	....	..... .	.. ..	Smooth.	....	....
Remarks	Not rigged; fine stern.	....	....	....	....	....	....	....	Rigged and fully equipped.	....	Fully rigged and ready for sea.	....	....	....
Reference to Reports	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.

* Half boiler power.

TABLE IV. (*continued.*)

Groups of a Speed	2. Between 7 and 9 knots.											
Subgroups of Displacement	E. Between 1000 and 2000 tons.											
Name of Vessel	Falcon.	Supply.	Harrier.	Archer.	Eurotas.	Malacca.	Cossack.	Phœnix.	Wyoming, U.S.	Niger. Half-boilerpr.	Conflict.	Forth.
Length on waterline, in feet	160	179·5	160	186·33	166·16	192	195	174·5	209·75	194·33	192·54	159
Breadth (extreme), in feet	31·83	27·12	31·83	33·83	40·83	34·33	38·5	31·83	33	34·67	34·33	42·16
Tonnage, builder's measurement	748	638	747	970	1201	1034	1322	809	997	1072	1038	1228
Mean draft of water, in feet	14	14·25	14·75	14·75	15·29	14·16	14·04	15·62	13·29	15·79	15·08	17·62
Area of immersed midship section, sq. ft.	330	324	356	378	387	377	383	405	391·	437	421	493
Displacement, in tons of 35 cubic feet	1006	1070	1097	1263	1293	1363	1365	1460	1475	1496	1530	1704
ENGINES.												
Description	Hor.	In. Sing. Tr.	Hor.	H. geared.	H. Tr. H. P	H. Tr. H. P.	Hor.	V. o. geared.	Hor.	Hor.	Hor.	H. Tr. H. Pr.
Number of cylinders	2	2	2	2	2	2	2	2	2	4	4	2
Diameter of cylinders, in inches	32	=34·5	54	46·01	=30·25	=23	51	62·25	50	47·625	46·25	=30·25
Length of stroke, in feet	2	2·25	1·75	3	2·5	2·5	2·25	4·5	2·5	1·83	2	2·5
Number of revolutions, per minute	81·5	45	93·83	42	93·33	87	66·33	22	52·5	55	72	110
Weight per sq. in. on safety-valve, in lbs.	20	14	20	10	60	60	12	10	17	12	10	60
Nominal horse-power	100	80	100	200	200	200	250	260	......	400	400	200
Indicated horse-power	312·2	265·2	323·5	447·1	561·8	675	573·4	524·1	....	431·8	790	814
PROPELLER.												
Diameter, in feet	10·02	10	10	9	12	13·5	12·08	11·87	13·08	12·5	13·52	12
Pitch, in feet	11·77	12	11·12	7·25	10	11·12	16·57	9·83	19	17·25	16·37	10
Length in line of shaft	1·98	1·67	1·92	1·33	1·67	1·85	2·75	1·60	2·5	2·48	2·73	1·67
Immersion of lower ledge, in feet	7	8·57	8·33	7·08	10·57	6·25	6·57	6·75	....	8·25	7·83	11·57
Number of revolutions, per minute	81·5	45	93·83	126	93·33	87	66·33	88	52·5	55	72	110
Speed of ship, in knots per hour	7·87	8	7·655	7·8	7·579	8·708	8·655	7·674	7·1	7·6	8·85	8·6
Speed of propeller, in knots per hour	9·465	10·653	10·297	9·011	9·206	9·547	10·851	8·536	....	9·359	11·630	10·851
$Speed^3 \times D^{\frac{2}{3}} \div$ indicated horse-power	156·7	202	147·5	124	92	120·3	139·1	....	....	133	116·5	....
Wind	No. 3.	....	No. 3.	....	....	No. 2.	....	....	....	....	No. 3 to No. 4.	Fresh breeze.
Sea	....	....	....	....	....	....	....	....	....	....	Light swell.	Little swell.
Remarks	....	....	....	....	Vessel not in trim.	....	....	....	....	....	....	....
Reference to Reports	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.

TABLE IV. (*continued.*)

Groups of a Speed	2. Between · and 9 knots.												
Subgroups of Displacement	F. Between 2000 and 4000 tons.											G. Between 4000 and 8000 tons.	
Name of Vessel	Russell.	Pembroke.	Arrogant.	Edinburgh.	Majestic.	Hogue.	Hannibal.	Brunswick.	Centurion.	Cressy.	Sanspareil.	Nile.	Niagara, U.S.
Length on waterline, in feet	176.5	176	200	176·5	190	184	217·5	190	190	198·42	200	205.5	328·87
Breadth (extreme), in feet	48·33	48·5	45·73	48·61	56·75	48·37	48·13	55 75	57·08	55	52·25	54·29	53·67
Tonnage, builder's measurement	1751	1758	1872	1772	2590	1846	3136	2484	2590	2540	2339	2622	………
Mean draft of water, in feet	12·85	19·5	19·41	22·12	21·75	22·49	20·55	24·24	24·37	24·41	24·14	24·96	22
Area of immersed midship section, sq. feet	585	660	604	785	749	805	777	882	895	855	994	1013	856
Displacement, in tons of 35 cubic feet	2106	2465	2565	3005	3028	3081	3300	3632	3680	3707	3800	4480	5075
ENGINES.													
Description	H. Tr. H. P.	H. H. P.	H. trunk.	Hor.	Hor.	Hor.	H. geared.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.
Number of cylinders	2	2	2	4	2	4	2	2	2	2	2	4	3
Diameter of cylinders, in inches	=30·25	30	=55	55	64	51·5	71·25	64	64	64	64	62·25	72
Length of stroke, in feet	2·5	2·5	3	2·5	3	3	4	3	3	3	3	3·5	3
Number of revolutions, per minute	103	82	64·833	52	49·4	56	27·5	53·5	54	48·2	58	30	45
Weight per sq. in. on safety-valve, in lbs.	60	65	12	6	20	10	12	20	20	20	15	16	19
Nominal horse-power	200	200	360	450	400	450	450	400	400	400	400	500	700
Indicated horse-power	701·3	572	894·8	963·6	1199·1	797·3	1071·2	1438	1255	1076·3	1471	1247·3	195·509
PROPELLER.													
Diameter, in feet	12	12	15·5	16	17	16·06	17	17	17	17	16	17	18·27
Pitch, in feet	9·5	12	15·46	18·75	21	18·75	12·5	20·57	21	21	23	16	31·27
Length in line of shaft	1·57	2	2·42	3·08	3·5	3·33	2·08	3	3	3·08	3	2·67	1·888
Immersion of lower ledge, in feet	10·46	12·08	10·16	11·71	11·57	12·5	8·83	14·16	13·57	12·92	14·20	13·92	………
Number of revolutions, per minute	103	82	64·833	52	49·4	56	64·87	53·5	54	48·2	58	60	45
Speed of ship, in knots per hour	7·5	7·602	8·935	8·498	8·783	8·328	8·6	7·742	8·5	7·206	9·3	8·2	10·9
Speed of propeller, in knots per hour	9·652	9·706	9·886	9·618	10·233	10·357	7·999	10·862	11·186	9·984	13·159	9·470	13·88
$\text{Speed}^3 \times \text{D}t^{\frac{2}{3}} \div$ indicated horse-power	98·8	………	149·4	………	118·3	………	………	………	………	83·3	………	120·1	………
Wind	………	No. 2.	No. 3.	………	………	………	………	No. 7, very strong.	Fresh breeze.	………	Calm.	Light breeze.	………
Sea	………	………	………	………	………	………	………	………	Considerable swell.	………	Smooth.	Smooth.	………
Remarks	………	………	………	………	………	Fully rigged and complete with sea stores.	Launching; cleats not removed.	………	………	………	………	………	………
Reference to Reports	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.

Table V.—Men-of-War (Group 3).

Groups of a Speed	3. Between 9 and 11 knots.					
Subgroups of Displacement	A. Under 125 tons.	C. Between 250 and 500 tons.				
Name of Vessel	Dwarf.	Dart.	Lee.	Snipe.	Sparrow.	Nimble.
Length on waterline, in feet	130	145	145	145	145	145
Breadth (extreme), in feet	16·5	25·33	25·33	25·33	25·33	25·33
Tonnage, builder's measurement	164	425	425	425	425	425
Mean draft of water, in feet	5·5	9·08	9·12	9·16	9·20	9·25
Area of immersed midship section, sq. ft.	44	166	167	168·5	169·5	170·5
Displacement, in tons of 35 cubic feet	98	390	392·5	395	398	401
Engines.						
Description	Vert.	Hor.	Hor.	Hor.	Hor.	Hor.
Number of cylinders	2	2	2	2	2	2
Diameter of cylinders, in inches	40	32	32	32	32	30
Length of stroke, in feet	2·67	1·5	1·5	1·5	1·5	1·67
Number of revolutions, per minute	35·5	101	98	103	108	100
Weight per sq. in. on safety-valve, in lbs.	8	20	20	20	20	20
Nominal horse-power	90	80	80	80	80	80
Indicated horse-power	216	361·7	343·1	363·4	391·8	334
Propeller.						
Diameter, in feet	5·67	9	9	9	9	9
Pitch, in feet	8	12·33	12·33	12·33	12·33	11·75
Length in line of shaft	1	2	2	2	2	2
Immersion of lower ledge, in feet	... .	4·67	5	5·25	5·33	4·67
Number of revolutions, per minute	182·8	101	98	103	108	100
Speed of ship, in knots per hour	10·537	10·19	10·022	10·32	10·872	9·933
Speed of propeller, in knots per hour	14·427	12·287	11·922	12·531	13·139	11·590
$\text{Speed}^3 \times Dt^{\frac{2}{3}} \div$ indicated horse-power	....	156·2	157·2	162·8	177·5	159·6
Wind	....	....	....	....	....	....
Sea	....	....	....	....	....	....
Remarks	Not rigged.	....	....	....	....	....
Reference to Reports	1862.	1862.	1862.	1862.	1862.	1862.

Groups of a Speed	3. Between 9 and 11 knots.									
Subgroups of Displacement	C. Between 250 and 500 tons.				D. Between 500 and 1000 tons.					
Name of Vessel	Mullet.	Espoir.	Griffon.	Snake.	Sharp-shooter.	Beagle.	Ranger.	Philomel.	Gannet.	Cordelia.
Length on waterline, in feet	145	145	145	160	150	160	145	145	151	151
Breadth (extreme), in feet	25·33	25·33	25·33	25·33	26·61	25·33	25·33	25·33	29·08	29·08
Tonnage, builder's measurement	425	425	425	477	503	477	425	425	577	577
Mean draft of water, in feet	9·24	9·45	9·46	9·62	9·25	10·125	11·33	11·58	10·87	11
Area of immersed midship section, sq. ft.	170·5	176	176	179	196	192	223	230	202	204
Displacement, in tons of 35 cubic feet	401	416	416	482	518	523	550	570	583	591
Engines.										
Description	Hor.	Hor.	Hor.	H. trunk.	Hor.	Hor.	H.sing.T.	Hor.	Hor.	Hor.
Number of cylinders	2	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches	32	30	32·125	=35·1	46	42·125	=30·2	32	39	38
Length of stroke, in feet	1·5	1·67	1·5	1·67	3	1·75	1·5	1·5	2	2
Number of revolutions, per minute	102	98	101	109·83	41·5	72	95·5	108	90·6	78
Weight per sq. in. on safety-valve, in lbs.	20	20	20	20	10	20	20	20	20	20
Nominal horse-power	80	80	80	160	200	160	80	80	150	150
Indicated horse-power	355·4	330·3	325·9	459·8	365·2	295	283·6	354·2	616·6	460·8
Propeller.										
Diameter, in feet	9	9	9	11	9	11·08	9	9	10	10
Pitch, in feet	12·33	11·75	12·33	10	9	14·71	11·5	12·18	14·5	16
Length in line of shaft	2	2	2	2·33	1·5	2·29	1·83	2·21	2·5	2·5
Immersion of lower ledge, in feet	5·16	4·83	5	3·67	....	4·42	6	6·42	4·5	5·67
Number of revolutions, per minute	102	98	101	109·83	124·5	72	95·5	108	90·6	78
Speed of ship, in knots per hour	10·067	10·05	10·119	10·303	9·189	9·409	9·006	9·548	10·817	9·912
Speed of propeller, in knots per hour	12·409	11·359	12·287	10·834	11·052	10·446	10·833	13·032	12·958	12·310
$\text{Speed}^3 \times Dt^{\frac{2}{3}} \div$ indicated horse-power	156·1	171·3	177·2	146·2	....	183·3	172·9	168·9	143·3	148·8
Wind	....	No. 5.	No. 4 to No. 5.	....	....	No. 1 to No. 2.	No. 3 to No. 4.	No. 3 to No. 4.	Calm.	Light breeze.
Sea	....	Smooth.	....	....	....	....	....	....	Smooth.	Little swell.
Remarks	....	....	....	....	Rigged and partially equipped.	....	....	Rigged and stored.	....	....
Reference to Reports	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862,	1862.

Table V. (continued.)

Groups of a Speed: **3.** Between 9 and 11 knots.

Subgroups of Displacement: **D.** Between 500 and 1000 tons.

Name of Vessel	Alacrity.	Icarus.	Eclipse.	Lily *.	Surprise.	Wanderer.
Length on waterline, in feet	180	151	185	185	180	180
Breadth (extreme), in feet	28·33	29·08	28·33	28·33	28·33	28·33
Tonnage, builder's measurement	670	577	695	695	670	670
Mean draft of water, in feet	9·25	11	9·33	9·83	9·5	9·57
Area of immersed midship section, sq. feet	195	211	198	200	203·5	206
Displacement, in tons of 35 cubic feet	605	618	625	634	637	645
Engines.						
Description	Hor.	H.sin.Tr.	Hor.	Hor.	Hor.	Hor.
Number of cylinders	2	2	2	2	2	2
Diameter of cylinders, in inches	45	=38·875	45	45	45	45
Length of stroke, in feet	2	1·83	2	2	2	2
Number of revolutions, per minute	85·5	92	96	76	93	88·5
Weight per sq. in. on safety-valve, in lbs.	20	20	20	20	20	20
Nominal horse-power	200	150	200	200	200	200
Indicated horse-power	587·2	602·8	838·4	474·1	721·4	627·8
Propeller.						
Diameter, in feet	11	10	11	11	11	11
Pitch, in feet	16	14·42	16·5	17	15·83	16·54
Length in line of shaft	2·5	2·19	2·42	3·25	2·5	2·67
Immersion of lower ledge, in feet	3·42	5·67	3·92	4·83	3·92	3·5
Number of revolutions, per minute	85·5	92	96	76	93	88·5
Speed of ship, in knots per hour	10·651	10·146	11	10	10·81	10·258
Speed of propeller, in knots per hour	13·494	13·083	15·625	12·744	14·525	14·440
$\text{Speed}^3 \times \text{Dt}^{\frac{2}{3}} \div$ indicated horse-power	147·2	125·7	116·1	155·7	129·6	128·4
Wind	....	....	....	....	....	No. 3.
Sea	....	....	....	....	Smooth.	....
Remarks	....	....	....	....	....	....
Reference to Reports	1862.	1862.	1862.	1862.	1862.	1862.

Name of Vessel	Rosario.	Rapid.	Coquette.	Fawn.	Ring-dove.	Race-horse.	Alert.	Lapwing.	Mohawk.	Vigilant.
Length on waterline, in feet	160	160	180	160	180	185	160	180	180	180
Breadth (extreme), in feet	30·33	30·33	28·33	31·83	28·33	28·33	31·83	28·33	28·33	28·33
Tonnage, builder's measurement	669	669	670	748	670	695	748	670	670	670
Mean draft of water, in feet	11·5	11·71	11·41	11·33	10·21	10·16	11·41	10·83	10·87	11·04
Area of immersed midship section, sq. feet	222	228	242	247	223	221	250	240	242	245·5
Displacement, in tons of 35 cubic feet	646	666	790	709	714	718	718	781	785	803·5
Engines.										
Description	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.
Number of cylinders	2	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches	38	38	45	32	45	45	32	45	42·25	45
Length of stroke, in feet	2	2	2	2	2	2	2	2	2·16	2
Number of revolutions, per minute	93	100	82·25	92·5	84	85	92	85	88	84
Weight per sq. in. on safety-valve, in lbs.	24	20	20	20	20	20	20	20	20	20
Nominal horse-power	150	150	200	100	200	200	100	200	200	200
Indicated horse-power	615·2	613	690	406·9	676·8	731·6	387·4	689·2	641·5	629·9
Propeller.										
Diameter, in feet	10	10	11	10	11	11	10	11	11·08	11
Pitch, in feet	14	13	16	12	15·71	16·5	12	15·65	14·25	16·46
Length in line of shaft	2·5	3	2·5	2	2·5	2·46	2	2·5	2·56	2·64
Immersion of lower ledge, in feet	5·33	5·75	4·57	5·33	4·16	4·67	5·25	4·42	4·42	4·57
Number of revolutions, per minute	93	100	82·25	92·5	84	85	92	85	88	84
Speed of ship, in knots per hour	10·08	10·2	10·853	9·21	10·824	10·937	9·607	11·021	10·721	9·763
Speed of propeller, in knots per hour	12·843	12·823	12·981	10·949	13·016	13·834	10·890	13·101	12·370	13·257
$\text{Speed}^3 \times \text{Dt}^{\frac{2}{3}} \div$ indicated horse-power	124·4	132	....	152·7	....	143·4	183·5	....	....	127·7
Wind	....	....	No. 3.	....	No. 1.	No. 3 to No. 4.	Light.	No. 2.	No. 2 to No. 3.	No. 5 to No. 6.
Sea	....	....	....	....	....	....	Smooth.	....	....	....
Remarks	....	....	....	....	....	....	Without masts or rigging.	....	....	Steam maintained at not more than 18 lbs.
Reference to Reports	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.

* Half-boiler power.

TABLE V. (*continued*.)

Groups of a Speed	3. Between 9 and 11 knots.						
Subgroups of Displacement........	D. Between 500 and 1000 tons.						
Name of Vessel................	Osprey.	Racer.	Victor.	Industry.	Zebra.	Intrepid.	Rattler.
Length on water-line, in feet	180	151	200	179·5	185	200	176·5
Breadth (extreme), in feet	28·33	29·08	30·16	27·12	33·16	30·16	32·71
Tonnage, builder's measurement..	670	577	851	638	950	851	888
Mean draft of water, in feet ..	11·20	13·37	10·04	12·66	11·83	11·29	13·79
Area of immersed midship sect. sq. ft.	250·5	272	233	281	277	270	338
Displacement, in tons of 35 cub. ft	826·5	829	875	903	912	1040	1112
ENGINES.							
Description	Hor.	Hor.	Hor.	Oscil.	Hor.	Hor.	V. d. c. g.
Number of cylinders ....*.	2	2	2	2	2	2	4
Diameter of cylinders, in inches	45·06	40	55	36·5	42·5	58·06	40·125
Length of stroke, in feet	2	1·67	2·5	3	2·16	2·25	4
Number of revolutions, per minute	80	96·5	84·5	42	112	70	25·43
Wt. per sq. in. on safety valve, in lbs	20	22	20	12	20	20	10
Nominal horse-power	200	150	350	100	200	350	200
Indicated horse-power	593·4	522·2	973·8	317·8	984·8	930·1	519·2
PROPELLER.							
Diameter, in feet	11·04	10	11	9	12	11	10
Pitch, in feet	15·83	13·5	20·5	11	15	21·25	11
Length in line of shaft	2·59	2·19	3	1·83	2·75	3·02	1·25
Immersion of lower ledge, in feet	4·5	6·92	4·16	6·92	4·25	5·16	7·5
Number of revolutions, per minute	80	96·5	84·5	97·548	112	70	101·72
Speed of ship, in knots per hour	10·15	9·519	9·056	9·12	10·714	10·25	9·141
Speed of propeller, in knots per hour	12·495	12·85	17·087	10·585	16·572	14·673	10·037
Speed^3 × Dt$^{\frac{2}{3}}$ ÷ indicated h.-p.......	155·2	145·8	69·8	223·1	117·4	118·9	159
Wind	......	No. 3.	......	......	.. ...	......	......
Sea	......	......	.. ...	......	......	Smooth.	......
Remarks	......	......	Bottom foul.	.. ...	......	. ...	......
Reference to Reports	1862.	1862.	1862.	1862.	1862.	1862.	1862.

Groups of a Speed	3. Between 9 and 11 knots.									
Subgroups of Displacement	E. Between 1000 and 2000 tons.									
Name of Vessel	Chameleon.	Flying Fish.	Greyhound.	Mutine.	Rinaldo.	Fox.	Miranda.	Tartar.	Brisk.	Encounter.
Length on water-line, in feet	185	218	172·5	172·5	185	159·33	196·04	195	193·57	190
Breadth (extreme), in feet	33·16	30·33	33·16	33·16	33·16	40 33	34	38·5	35	43·20
Tonnage, builder's measurement	950	950	878	878	950	1131	1039	1322	1074	953
Mean draft of water, in feet	13·54	11·92	13 78	14	14·62	16·29	12·37	13·96	13·75	13·70
Area of immersed midship sect. sq. ft.	332	286	342	349	367 4	449	336	379	350	382
Displacement, in tons of 35 cub. ft	1138	1161	1175	1200	1286	1340	1350	1350	1370	1459
ENGINES.										
Description	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	H. geared.	Hor.	Hor	H. trunk.
Number of cylinders	2	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches	45	58 06	45	45	42·5	45	56·375	51	52	=55
Length of stroke, in feet	2	2·25	2	2	2·16	2	3·75	2·25	3·5	2·25
Number of revolutions, per minute	80·8	74·5	80 5	82	92·083	93	28 5	72·25	39	81·75
Wt. per sq. in. on safety valve, in lbs	20	20	20	20	20	20	13	14	14	12
Nominal horse-power	200	350	200	200	200	200	250	250	250	300
Indicated horse-power	584·2	1222·6	744 9	786·4	752·4	740·8	613·1	731	595·6	844
PROPELLER.										
Diameter, in feet	12·33	13·16	12·33	12·33	12	12·04	12	12·08	12	12
Pitch, in feet	13·5	19·96	14 5	13·5	13·87	10·86	11·5	16·5	12·16	15·75
Length in line of shaft	2·29	3	2·42	2·67	2·12	2	1·92	2·75	2	2·67
Immersion of lower ledge, in feet	5·33	5·75	5·67	6·16	7·33	9·42	5·25	6·16	6·33	6·54
Number of revolutions, per minute	80·8	74·5	80·5	82	92 083	93	87·87	72·25	87·75	81·75
Speed of ship, in knots per hour	10·206	12·43	9·87	10·25	10·588	9·325	10·75	9·4	9·035	10·699
Speed of propeller, in knots per hour	10·742	14·667	11·448	10·92	12 603	10·884	9·968	11·759	10·531	12·735
Speed^3 × Dt$^{\frac{2}{3}}$ ÷ indicated h.-p.	198 4	173·5	143·7	154·6	186·6	133	......	138·8	152·8	......
Wind	Light.	No. 2.	Light.	......	No. 3.	No. 3.	No. 5 abeam.	No. 5 to No. 6.	No. 4 to No. 5.	Calm.
Sea	......	.... .	Smooth.	......	......	......	......	......	......	......
Remarks	......	... .	......	......	Fully equipped for sea.	......	......	... ..	......	Fully rigged.
Reference to Reports	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.

TABLE V. (continued.)

Groups of a Speed	3. Between 9 and 11 knots.					
Subgroups of Displacement	E. Between 1000 and 2000 tons.					
Name of Vessel	Niger.	Megæra.	Desperate.	Termagant.	Highflyer.	Seahorse.
Length on waterline, in feet	194·33	207	192·33	210·08	192	159
Breadth (extreme), in feet	34·67	37·83	34·35	40·5	36·33	41·83
Tonnage, builder's measurement	1072	1395	1037	1547	1153	1212
Mean draft of water, in feet	15·79	13·29	15·96	14·05	16·5	18·21
Area of immersed midship section, sq. ft.	437	383	452	436	476	518
Displacement, in tons of 35 cubic feet	1497	1554	1663	1670	1775	1799
Engines.						
Description	Hor.	Hor.	H. geared	Hor.	Hor.	H.T.H.P.
Number of cylinders	4	4	4	2	2	2
Diameter of cylinders, in inches	47·625	49·5	55·01	62·5	55·18	=30·25
Length of stroke, in feet	1·83	2	2 5	3	2·5	2·5
Number of revolutions, per minute	78	74·21	37	62	53·37	112·25
Weight per sq. in. on safety-valve, in lbs.	12	8	10	15	. .	60
Nominal horse-power	400	350	400	400	250	200
Indicated horse-power	1002·1	925·6	891·7	1205·6	702	832·4
Propeller.						
Diameter, in feet	12·5	14·46	13·08	15·61	12·06	12
Pitch, in feet	17·25	16	13·83	24	9 71	10
Length in line of shaft	2·45	2·73	2·25	2·87	1·67	1·67
Immersion of lower ledge, in feet	8·25	6·67	8·42	5·5	8·33	11·08
Number of revolutions, per minute	78	74·21	80·727	62	106·74	112·25
Speed of ship, in knots per hour	10·25	10·241	9·6	10·66	9·399	9·298
Speed of propeller, in knots per hour	13·272	11·711	11·016	14·678	10·222	11·072
$\text{Speed}^3 \times Dt^{\frac{2}{3}} \div$ indicated horse-power	140·6	......	139·3	141·4	......	......
Wind	......	......	Light breeze.	No. 4.	. ...	No. 3.
Sea	......	......	Smooth.	......	......	......
Remarks	......	......	......	......	......	......
Reference to Reports	......	......	......	......	......	......

Groups of a Speed	3. Between 9 and 11 knots.									
Subgroups of Displacement	E. Between 1000 and 2000 tons.			F. Between 2000 and 4000 tons.						
Name of Vessel	Esk.	Greenock.	Pylades.	Challenger.	Pearl.	Racoon*.	Satellite.	Satellite*.	Tribune.	Assistance.
Length on waterline, in feet	192	213	192·75	200	200	200	200	200	192	282·87
Breadth (extreme), in feet	36·25	37·40	38·42	40·33	40·33	40·33	40·33	40·33	43	36·39
Tonnage, builder's measurement	1169	1418	1278	1462	1462	1462	1462	1462	1570	1793
Mean draft of water, in feet	16·87	14·20	17·5	17·43	17·92	17·96	18·08	18·08	18·5	16·62
Area of immersed midship section, sq. ft.	488	419	522	522	538	540	546	546	578	440
Displacement, in tons of 35 cubic feet	1835	1835	1956	2018	2107	2115	2138	2138	2220	2260
Engines.										
Description	In. oscil.	Hor.	H. trunk.	H. trunk.	H. trunk.	Hor.	H. trunk.	H. trunk.	Hor.	H. S. Tr.
Number of cylinders	2	2	2	2	2	2	2	2	2	4
Diameter of cylinders, in inches	50	71	=55	=58·11	=58·11	64	=58·11	=58·11	55	=45·16
Length of stroke, in feet	2·75	4	3	3·25	3·25	3	3·25	3·25	2·5	3
Number of revolutions, per minute	68	32	62·5	54·6	55·25	56	57	47·5	72·5	45·083
Weight per sq. in. on safety-valve, in lbs.	18	......	20	20	20	20	20	20	20	12
Nominal horse-power	250	564	350	400	400	400	400	400	300	400
Indicated horse-power	721	719·3	1106	1190·8	1078·1	1485	1213·5	700·4	1068	878·8
Propeller.										
Diameter, in feet	12·20	14	15·75	16	16	16	16	16	14·08	17·18
Pitch, in feet	17·5	13	20	23·5	22·92	26	23·5	23·5	17·57	22·62
Length in line of shaft	......	2·16	3	3	3	3	3	3	2·87	2·75
Immersion of lower ledge, in feet	8·75	......	8·83	7·67	8·83	8·92	8·92	8·92	9·83	7·67
Number of revolutions, per minute	68	75·2	62·5	54·6	55·25	56	57	47·5	72·5	54·083
Speed of ship, in knots per hour	9·25	9 59	10·119	10·601	10·988	10·918	10·55	9·366	10·418	10·663
Speed of propeller, in knots per hour	11·738	9·643	12·330	12·656	12·49	14·362	13·213	11·011	12·575	12·075
$\text{Speed}^3 \times Dt^{\frac{2}{3}} \div$ indicated horse-power	......	......	......	159·8	202·2	144·3	160·6	194·7	......	237·6
Wind	......	......	No. 4.	No. 5 to No. 6.	No. 2.	No. 3 to No. 4.	Fresh breeze.	Fresh breeze.	No. 2.	No. 2 to No. 3.
Sea	......	......	......	......	......	......	Little swell.	Little swell.	......	......
Remarks	......	......	......	......	......	......	......	......	......	......
Reference to Reports	......	......	......	......	......	......	......	......	......	......

* Half-boiler power.

TABLE V. (*continued.*)

Groups of a Speed	3. Between 9 and 11 knots.					
Subgroups of Displacement	F. Between 2000 and 4000 tons.					
Name of Vessel	Adventure.	Vulcan.	Lion.	Simoon.	Phœbe*.	Goliath.
Length on waterline, in feet	282·87	220	192	246	240·5	190
Breadth (extreme), in feet	36·37	41·42	57	41	51·5	56·75
Tonnage, builder's measurement	1793	1764	261	1980	2848	2590
Mean draft of water, in feet	17·21	17·20	19·75	15·95	17·95	20·04
Area of immersed midship section, sq. ft.	461	553	635	528	573	684
Displacement, in tons of 35 cubic feet	2388	2520	2540	2550	2700	2737
ENGINES.						
Description	H. S. Tr.	Hor.	H. trunk.	Hor.	Hor.	H. trunk.
Number of cylinders	4	2	2	2	2	2
Diameter of cylinders, in inches	=45·16	64	=58·11	62·5	65	=58·11
Length of stroke, in feet	3	3	3·25	3	3	3·25
Number of revolutions, per minute	51·75	48·375	66	57	50·5	60
Weight per sq. in. on safety-valve, in lbs.	10	10	20	20	20	20
Nominal horse-power	400	400	400	400	500	400
Indicated horse-power	824·9	857·3	1771·2	1255·3	844·3	1437·5
PROPELLER.						
Diameter, in feet	17·18	17·08	17	15·92	18	18·5
Pitch, in feet	22·62	22·87	18·5	24·57	22	17
Length in line of shaft	2·75	3	3	2·71	3·25	3
Immersion of lower ledge, in feet	8·33	10·67	10·42	8·08	7·5	10·57
Number of revolutions, per minute	51·75	48·375	66	57	50·5	60
Speed of ship, in knots per hour	10·316	9·511	10·911	10·861	9·959	9·16
Speed of propeller, in knots per hour	11·555	10·915	12·044	13·822	10·959	10·949
$Speed^3 \times D^{\frac{2}{3}} \div$ indicated horse-power	237·8	185·8	136·5	190·5	226·8	104·6
Wind	No. 4.	No. 5 to No. 6.	Light breeze.	No. 5 to No. 6.	No. 4.	No. 3.
Sea	......	......	Little swell.	......	Moderate swell.	......
Remarks	......	Supply of steam deficient.	.. ..	......	......	......
Reference to Reports	......	......	......	......	......	......

Name of Vessel	Phæton.	Colossus.	Impérieuse.	London*.	Aboukir.	Nelson*.	Windsor Castle.	Cæsar.	Royal George.	Chesapeake.
Length on waterline, in feet	220·26	190	212	215·25	204	216·25	204	207·33	205·57	212
Breadth (extreme), in feet	49·83	57	50	54·29	60	54·5	60·04	56·06	54·54	50
Tonnage, builder's measurement	2396	2590	2355	2687	3091	2736	3101	2767	2616	2356
Mean draft of water, in feet	19·87	21·04	20·49	19·83	20·5	19·66	20·25	21·04	20·16	21·66
Area of immersed midship section, sq. ft.	657	708	688	735	740	750	770	726	760	746
Displacement, in tons of 35 cubic feet	2840	2855	3044	3115	3150	3158	3245	3250	3270	3334
ENGINES.										
Description	Hor.	H. trunk.	H. trunk.	Hor.	H. trunk.	Hor.	H. trunk.	H. trunk.	H. trunk.	Hor.
Number of cylinders	2	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches	64	=58·25	=55	70·07	=58·25	71	=64·33	=58	=58·11	64
Length of stroke, in feet	3	3·25	3	3	3·25	3	3·33	3·25	3·25	3
Number of revolutions, per minute	57·33	61·83	68	49	62·3	54·66	68·5	60	60·33	52
Weight per sq. in. on safety-valve, in lbs.	22	20	20	20	20	20	20	22	20	20
Nominal horse-power	400	400	360	500	400	500	500	400	400	400
Indicated horse-power	1566·2	1420·6	1199·8	878·7	1533·3	1190·8	2052·3	1420	1397·9	1159·2
PROPELLER.										
Diameter, in feet	17	17·12	15·96	18	17	18	17	17·12	17	17
Pitch, in feet	24	18·46	17	20	17·5	20·16	18·5	18·89	18	22·5
Length in line of shaft	3	2·89	2·61	3	3	3·75	3	2·96	3	3
Immersion of lower ledge, in feet	10	10·42	11·25	9·83	10·16	9·83	10·75	11·42	10	11·75
Number of revolutions, per minute	57·33	61·83	68	49	62·3	54·66	63·5	60	60·33	52
Speed of ship, in knots per hour	10·466	9·66	10·111	9·508	9·55	10·363	10·955	10·274	9·568	9·658
Speed of propeller, in knots per hour	13·573	11·258	11·403	9·667	10·754	10·875	12·503	11·183	10·712	11·541
$Speed^3 \times D^{\frac{2}{3}} \div$ indicated horse-power	146·8	134·9	181	208·6	122·1	201·2	140·4	......	138	173·4
Wind	No. 5 to No. 6.	......	No. 4.	No. 4.	No. 7 to No. 8.	No. 3.	No. 4.	No. 1.	Calm.	No. 4 to No. 5.
Sea	......	......	......	Little swell.	Heavy swell.	......	......	......	Smooth.	......
Remarks	......	......	......	......	......	......	......	......	......	......
Reference to Reports	......	......	......	......	......	......	......	......	......	......

* Half-boiler power.

* Half-boiler power.

TABLE V. (*continued.*)

Groups of a Speed	3. Between 9 and 11 knots.															
Subgroups of Displacement	F. Between 2000 and 4000 tons.						G. Between 4000 and 8000 tons.									
Name of Vessel	Narcissus.	Royal William.	Algiers*.	Immortalité*.	Trafalgar.	Queen.	Exmouth.	Saint George.	Orion.	Neptune	Agamemnon.	Duke of Wellington.	Victor Emanuel*.	Victor Emanuel.	James Watt.	Renown*.
Length on waterline, in feet	228	216·75	218·57	251	216	214	204	216·5	238	216·5	230	240·5	230	230	230	244·75
Breadth (extreme), in feet	51·25	55·75	60	52·08	55·46	60	60	54·37	55·75	55·42	55·33	60	55·33	55·33	55·42	55·33
Tonnage, builder's measurement	2665	2849	3347	3059	2900	3249	3083	2864	3232	2830	3074	3759	3087	3087	3083	3318
Mean draft of water, in feet	21·42	21·04	21	21·42	22·91	22·79	24·37	23·95	24·12	24·96	23·04	23·62	24·12	24·12	24·33	23·67
Area of immersed midship section, sq. ft.	706	820	814	715	880	910	968	966	894	1018	1012	988	1065	1065	1085	1050
Displacement, in tons of 35 cubic feet	3412	3520	3550	3625	3850	3930	4300	4313	4580	4589	4806	5080	5106	5106	5226	5320
ENGINES.																
Description	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	H. trunk.	Hor.	H. trunk.	H. geared.	Hor.	Hor.	Hor.	H. trunk.
Number of cylinders	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	2
Diameter of cylinders, in inches	64	65	76·125	76	66	66	64	71	=70·75	71	70·75	93·87	76·125	76·125	52·25	=82
Length of stroke, in feet	3	3	3·5	3·5	3·5	3·5	3	3	3·5	3	3·5	4·5	3·5	3·5	3	4
Number of revolutions, per minute	63·5	62·5	47·75	46	62·166	63·83	53	59·5	54	63·5	60·58	29·5	45·75	56·75	52	43·5
Weight per sq. in. on safety-valve, in lbs.	20	20	20	20	20	20	20	20	20	20	20	15	20	20	16	20
Nominal horse-power	400	500	600	600	500	500	400	500	600	500	600	700	600	600	600	800
Indicated horse-power	1701·1	1763·1	1361·8	1337·7	2275·1	2282·6	1252·4	1730·4	1956·7	2002·5	1948·5	1979	1273·8	2423·8	1531	1427
PROPELLER.																
Diameter, in feet	17	18	18·12	19·42	18	18	17	18	18	18	18	18	18·16	18·16	17	19
Pitch, in feet	18·5	20	26·08	25·5	19	19	21	20	23	19·75	21·83	16·25	26·16	26·16	24	28
Length in line of shaft	3·57	3	3	3·39	3·04	3·5	3·03	3	3·16	3	3·33	2·81	3·08	3·08	3	3·5
Immersion of lower ledge, in feet	11·67	10·42	10·75	9·5	11·33	11·5	13·42	12·57	12·25	14·42	13·33	11·92	12·83	12·83	13	11·16
Number of revolutions, per minute	63·5	62·5	47·75	46	62·166	63·83	53	59·5	54	63·5	60·58	66·6	45·75	56·75	52	43·5
Speed of ship, in knots per hour	10·936	10·581	10·487	10·94	10·908	10·578	9·1	10·933	10·1	10·897	10·717	10·15	9·072	10·874	9·5	9·145
Speed of propeller, in knots per hour	11·588	12·330	12·286	11·571	11·651	11·963	10·979	11·738	12·251	12·371	13·048	10·675	11·809	14·648	12·310	12·014
$\text{Speed}^3 \times Dt^{\frac{2}{3}} \div$ indicated horse-power	174·3	155·5	156·6	231	140·1	129·1	159·1	200·1	145·2	178·4	179·9	. ..	173·8	157·3	168·6	163·3
Wind	Light breeze.	Light breeze.	No. 4.	No. 2.	Calm.	No. 6.	......	No. 5.	Light breeze.	No. 2 to No. 3.	No. 4 to No. 5.	No. 4.	No. 4.	No. 4.	Light.	No. 4.
Sea	Little swell.	Little swell.	Slight wave.	......	Smooth.	Disturbed sea.	......	Moderate swell.	Smooth.	......	.. ...	......	......	......	Smooth.	......
Remarks	......	......	......	......	......	......	......	......	......	......	......	.. ...	......	......	......	......
Reference to Reports	......	......	......	......	......	......	......	......	......	......	.. ...	.. ...	......	......	.. ...	......

* Half-boiler power.

* Half-boiler power.

Table VI.—Men-of-War (Group 4).

Groups of a Speed	4. Between 11 and 13 knots.															
Subgroups of Displacement	C. Between 250 and 500 tons.			D. Between 500 and 1000 tons.										E. Between 1000 and 2000 tons.		
Name of Vessel	Cygnet.	Steady.	Penguin.	Arrow.	Fox-hound.	Lily.	Serpent.	Star.	Cormo-rant.	Sparrow-hawk.	Assu-rance.	Pelican.	Roebuck.	Pioneer.	Scout.	Pelorus.
Length on waterline, in feet	145·08	145	145	160	180	185	185	185	185	180	180	185	200	200	200	200
Breadth (extreme), in feet	25·42	25·33	25·33	25·33	28·33	28·33	28·33	28·33	28·33	28·33	28·33	33·16	30·16	30·33	40·33	40·33
Tonnage, builder's measurement	428	425	425	477	670	695	695	695	695	670	670	950	851	868	1462	1462
Mean draft of water, in feet	9·14	9·33	9·37	10·83	9·17	9·83	9·42	9·62	10·16	10·83	10·83	11·89	10·49	10·91	14·37	14·83
Area of immersed midship section, sq. ft.	168	173	174	209	194	200	200	206	221	240	240	279	246	262	399	417
Displacement, in tons of 35 cubic feet	393	407	410	586	601	634	634	657	718	781	781	920	935	1010	1478	1558
Engines.																
Description	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	H. trunk.	Hor.
Number of cylinders	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches	32	32	32	42	42	45	45	45	45	42·25	45	45	55	55	=58·11	64
Length of stroke, in feet	1·5	1·5	1·5	1·75	2·16	2	2	2	2	2·16	2	2	2·5	2·5	3·25	3
Number of revolutions, per minute	110	106	107	93	94	90	102	102	85	92	87	89·75	95·833	82	66	57
Weight per sq. in. on safety-valve, in lbs.	21	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Nominal horse-power	80	80	80	160	200	200	200	200	200	200	200	200	350	350	400	400
Indicated horse-power	354·2	360·4	364·6	594	599·5	799·1	907·3	892·3	722·8	725·6	744	758·5	1277·9	1150	1421·6	1437·6
Propeller.																
Diameter, in feet	9	9	9	11·04	11	11	11	11	11	11	11	12	11·08	11	15·94	16
Pitch, in feet	12·01	12·33	12·33	13	15	17	16·5	16·5	16·5	14·25	16	14·13	20·42	20·5	23·5	26
Length in line of shaft	1·97	2	2	2·30	2·54	3·25	2·46	2·42	2·46	2·58	2·5	2·42	3	3	3	3
Immersion of lower ledge, in feet	4·96	4·5	4·5	4·57	3	4·83	3·67	3·92	4·42	4·33	4·25	4·67	4·42	5	5·16	6·25
Number of revolutions, per minute	110	106	107	93	94	90	102	102	85	92	87	89·75	95·833	82	66	57
Speed of ship, in knots per hour	11·233	11·053	11·078	11	11·6	11·48	11·056	11·1	11·155	11·065	11·142	11·666	11·144	11·332	11·6	11·93
Speed of propeller, in knots per hour	13·032	12·896	13·017	11·926	13·908	15·092	16·601	16·601	13·834	12·932	13·731	12·514	19·300	16·582	15·299	14·619
$\text{Speed}^3 \times D^{\frac{2}{3}} \div$ indicated horse-power	214·7	205·8	205·8	....	185·4	139·7	109·9	115·8	154	....	....	198	103·6	....	142·5	158·7
Wind	No. 2.	....	....	....	....	....	....	....	No. 2.	No. 2 to No. 3.	Calm.	Calm.	No. 4 to No. 5.	No. 6 on the beam.	....	Light breeze.
Sea	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	Smooth.
Reference to Reports	1862.	1862.	1862.	1862.	1862.	1262.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.	1862.

TABLE VI. (continued.)

Groups of a Speed	4. Between 11 and 13 knots.					
Subgroups of Displacement	E. Between 1000 and 2000 tons.					
Name of Vessel	Clio.	Charybdis.	Orpheus.	Orestes.	Barossa.	Cadmus.
Length on waterline, in feet	200	200	225	225	225	200
Breadth (extreme), in feet	40·33	40·33	40·67	40·67	40·67	40·33
Tonnage, Builder's measurement	1462	1462	1702	1702	1702	1462
Mean draft of water, in feet	14·87	14·92	15·25	15·49	15·83	17·71
Area of immersed midship section, sq. ft.	419	421	443	453	466	537
Displacement, in tons of 35 cubic feet	1565	1572	1672	1720	1780	2065
ENGINES.						
Description	Hor.	Hor.	Hor.	Hor.	Hor.	Hor. T.
Number of cylinders	2	2	2	2	2	2
Diameter of cylinders, in inches	64	64	64	60·75	64	=58·11
Length of stroke, in feet	3	3	2·67	3	3	3·25
Number of revolutions, per minute	57·83	61·5	65	65	66	58·25
Weight per sq. in. on safety-valve, in lbs.	20	20	20	20	20	20
Nominal horse-power	400	400	400	400	400	400
Indicated horse-power	1539·2	1580·6	1445·2	1521·6	1798·2	1424
PROPELLER.						
Diameter, in feet	16	16	16	16	16	16
Pitch, in feet	26	26	23	23	24	23·5
Length in line of shaft	3	3	3·81	3·81	3	3
Immersion of lower ledge, in feet	6	4·83	6·16	6·08	6·57	8·33
Number of revolutions, per minute	57·83	61·5	65	65	66	58·25
Speed of ship, in knots per hour	11·96	11·752	12·449	12·265	11·92	11·294
Speed of propeller, in knots per hour	14·831	15·773	14·747	14·747	15·625	13·503
$\text{Speed}^3 \times Dt^{\frac{2}{3}} \div$ indicated horse-power	149·8	138·8	188·1	174·1	138·3	164·1
Wind	......	......	......	No. 5.	No. 2 to No. 3.	No. 4½.
Sea	......	......	......	......	......	Smooth.
Remarks	......	......	......	......	......	......
Reference to Reports	......	......	......	......	......	......

Groups of a Speed	4. Between 11 and 13 knots.									
Subgroups of Displacement	F. Between 2000 and 4000 tons.									
Name of Vessel	Racoon.	Jason.	Perseverance.	Urgent.	Forte.	Transit.	Severn.	Phoebe.	Melpomene.	Emerald.
Length on waterline, in feet	200	225	272·58	273·90	212	300	240·5	240·5	237	237
Breadth (extreme), in feet	40·33	40·67	38·5	38·54	50·08	41·5	50	51·5	52	52
Tonnage, Builder's measurement	1462	1702	1967	1981	2364	2522	2712	2848	2852	2852
Mean draft of water, in feet	18·37	18·5	18·04	18·37	17·74	18	18·57	17·95	18·53	18·91
Area of immersed midship section, sq. ft.	558	575·5	500·5	513	550	528·5	536	573	568	586
Displacement, in tons of 35 cubic feet	2192	2294	2299	2370	2370	2628	2638	2700	2741	2835
ENGINES.										
Description	Hor.	Hor	Hor. T.	Hor.	Hor.	Hor. T.	Hor.	Hor.	Hor. T.	Hor.
Number of cylinders	2	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches	64	64	=55	64	64	=58·5	66	65	=70·75	76
Length of stroke, in feet	3	3	3	3	3	3·25	3·5	3	3·5	3·5
Number of revolutions, per minute	58·66	54·5	57·5	59·25	56·33	56·75	67·166	62	59	54
Weight per sq. in. on safety-valve, in lbs.	21	20	16	15	20	15	20	20	20	20
Nominal horse-power	400	400	360	400	400	400	500	500	600	600
Indicated horse-power	1651·1	1549·2	911·8	1226·8	1538·9	1234·3	1977·6	1779·9	2171·4	2060·9
PROPELLER.										
Diameter, in feet	16	16	16·06	17	17	17	18	18	18·04	18
Pitch, in feet	26	26	21·97	22·33	22·5	24·25	20	22	25·02	28
Length in line of shaft	3	3·57	3·02	3·5	3	3	3	3·25	3·33	3·5
Immersion of lower ledge, in feet	9	9·67	8·5	9·42	7·5	9	8·67	7·5	7·08	7·83
Number of revolutions, per minute	58·66	54·5	57·5	59·25	56·33	56·75	67·166	62	59	54
Speed of ship, in knots per hour	11·416	11·632	11·297	11·996	11·485	11·909	12·132	11·9	12·436	12
Speed of propeller, in knots per hour	15·046	13·977	12·460	12 858	12·503	13·575	13·251	13·455	14·562	14·915
$\text{Speed}^3 \times Dt^{\frac{2}{3}} \div$ indicated horse-power	152·1	176·7	275·4	250·1	175	260·6	172·4	185·6	173·5	168
Wind	Calm.	No. 4.	Calm.	No. 2.	......	No. 4.	No. 4.	No. 4.	No. 3.	......
Sea	Smooth.	......	......	Smooth.	......	......	......	Mod. swell.	......	......
Remarks	......	......	......	......	......	......	......	......	......	......
Reference to Reports	......	......	......	......	......	......	......	......	......	......

Table VI. (*continued.*)

Groups of a Speed	4. From 11 to 13 knots.					
Subgroups of Displacement	F. Between 2000 and 4000 tons.					
Name of Vessel	Irresistible.	Topaze.	London.	Rodney.	Nelson.	Frederick William.
Length on waterline, in feet	190	235	215·25	214·33	216·25	214
Breadth (extreme), in feet	56·75	50	54·29	54	54·5	60
Tonnage, Builder's measurement	2642	2651	2687	2770	2736	3241
Mean draft of water, in feet	21·08	18·71	19·83	20·12	19·66	20·25
Area of immersed midship section, sq. ft.	708	635	735	737	750	770
Displacement, in tons of 35 cubic feet	2855	3000	3115	3126	3158	3245
Engines.						
Description	Hor. T.	Hor.	Hor.	Hor.	Hor.	Hor.
Number of cylinders	2	2	2	2	2	2
Diameter of cylinders, in inches	=58·11	76	70·875	66	71	66
Length of stroke, in feet	3·25	3·5	3	3·5	3	3·5
Number of revolutions, per minute	66	49	60·75	71·666	65·83	72·66
Weight per sq. in. on safety-valve, in lbs.	20	20	20	20	20	20
Nominal horse-power	400	600	500	500	500	500
Indicated horse-power	1668·5	2131·4	1804·1	2245·6	2101·8	2276·3
Propeller.						
Diameter, in feet	17	19·33	18	18	18	18·12
Pitch, in feet	17	29	20	16·5	20·16	17·79
Length in line of shaft	3·33	3·5	3	3	3·75	3·22
Immersion of lower ledge, in feet	11·25	7·5	9·83	9·67	9·83	10·92
Number of revolutions, per minute	66	49	60·75	17·166	65·83	72·66
Speed of ship, in knots per hour	11·01	12·16	11·522	11·479	11·533	11·776
Speed of propeller, in knots per hour	11·068	14·017	11·985	11·583	13·096	10·124
Speed^3 × Dt$^{\frac{2}{3}}$ ÷ indicated horse-power	161	175·5	180·8	144	157·1	157·2
Wind	......	No. 5 to No. 6.	No. 4.	No. 1 to No. 2.	No. 4.	No. 4.
Sea	......	Consid. swell.	Little swell.	......	......	......
Remarks	......	......	......	......	......	......
Reference to Reports	......	......	......	......	......	......

Name of Vessel	Princess Royal.	Waterloo.	Hood.	Algiers.	Bacchante.	Immortalité.	Doris.	Himalaya.	Diadem.
Length on waterline, in feet	217	218·20	238	218·57	235	251	240	340·42	240
Breadth (extreme), in feet	58·12	55·33	55·75	60	50	52·08	48	46·14	48
Tonnage, Builder's measurement	3129	2845	3232	3347	2651	3059	2479	3453	2479
Mean draft of water, in feet	20·90	20·79	20·58	21·07	21	21·45	20·49	18·83	20·54
Area of immersed midship section, sq. ft.	805	807	697	819	750	717	732	652	763
Displacement, in tons of 35 cubic feet	3400	3440	3470	3562	3631	3638	3714	3857	3880
Engines.									
Description	Hor.	Hor.	Hor. T.	Hor.	Hor.	Hor.	Hor. T.	Hor. T.	Hor.
Number of cylinders	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches	64·125	71	70·75	76·125	76	76	=82	=78	82
Length of stroke, in feet	3	3	3·5	3·5	3·5	3·5	4	3·5	4
Number of revolutions, per minute	58	62	62	57·66	55	55	53·71	55	56·33
Weight per sq. in. on safety-valve, in lbs.	20	20	20	20	20	20	20	12	20
Nominal horse-power	400	500	600	600	600	600	800	700	800
Indicated horse-power	1491	1889·9	2385·3	2518·4	2490·1	2392	3005	1830	2978·5
Propeller.									
Diameter, in feet	17·08	18	18	18·12	19·33	19·42	20·08	18·08	18
Pitch, in feet	2·54	20	23	26·08	25·79	25·5	30	28	33·42
Length in line of shaft	3	3·75	3·16	3	3·25	3·39	4·20	4·75	3·57
Immersion of lower ledge, in feet	9·79	10·33	9·42	10·83	10·33	9·5	9·75	9·92	10·42
Number of revolutions, per minute	58	62	62	57·66	55	55	53·71	55	56·33
Speed of ship, in knots per hour	11·031	11·329	11·752	12·191	12·074	12·538	12·158	12·5	12·003
Speed of propeller, in knots per hour	12·324	12·231	14·066	14·835	13·993	13·834	15·894	15·191	18·568
Speed^3 × Dt$^{\frac{2}{3}}$ ÷ indicated horse-power	......	175·3	156	167·8	167	197	143·4	262·5	143·4
Wind	No. 3 to No. 5.	No. 2 to No. 3.	No. 3.	No. 5.	No. 2 to No. 3.	No. 2 to No. 3.	No. 1 to No. 2.	Lit. breeze. Smooth.	Calm.
Sea	......	......	Smooth.	Slight wave.	......	......	......	......	......
Remarks	......	......	......	......	......	......	......	......	......
Reference to Reports	......	......	......	......	......	......	......	......	......

TABLE VI. (*continued.*)

Groups of a Speed	4. From 11 to 13 knots.												
Subgroups of Displacement	G. Between 4000 and 8000 tons.												
Name of Vessel	Royal Sovereign.	Gibraltar.	Prince of Wales.	Anson.	Edgar.	Hero.	Howe*.	Donegal.	St. Jean d'Acre.	Revenge.	Renown.	Mersey.	Marlborough.
Length on waterline, in feet	240·5	252	252	244·75	230·25	234·25	260	240	238	244·75	244·75	300	245·5
Breadth (extreme), in feet	60·	58	60·16	55·33	55·33	55·33	61	55·33	55·33	55·33	55·33	52	61·20
Tonnage, builder's measurement	3759	3716	3994	3317	3086	3127	4236	3224	3200	3318	3318	3727	4000
Mean draft of water, in feet	20·54	20·25	20·42	20·16	22·42	22·70	21·62	23·16	24·25	24	24·33	22·57	26·25
Area of immersed midship section, sq. ft.	802	832	800	856	977	993	949	1004	1067	1065	1082	917	11·89
Displacement, in tons of 35 cubic feet	4023	4120	4170	4190	4614	4765	4770	4960	5340	5446	55·20	5678	6035
ENGINES.													
Description	Hor.	Hor.	Hor. Tr.	Hor.	Hor.	Hor.	Hor. Tr.	Hor. Tr.	Hor. Tr.	Hor.	Hor. Tr.	Hor.	Hor.
Number of cylinders	2	2	2	2	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches	82	82	=82	82	76	76	=92·5	=82	=70·75	82	=82	92	82
Length of stroke, in feet	4	4	4	4	3·5	3·5	4	4	3·5	4	4	4	4
Number of revolutions, per minute	54	59	57·4	59	54·83	56	45·75	52·5	61	54·5	56·5	57·66	54·66
Weight per sq. in. on safety-valve, in lbs.	20	20	20	20	20	20	20	20	20	20	20	20	20
Nominal horse-power	800	800	800	800	600	600	1000	800	600	800	800	800	800
Indicated horse-power	2795	3504·8	3352	3582·6	2474·5	2662·1	2186·7	2832·3	2136	3028·2	3182·6	3877·8	3054·3
PROPELLER.													
Diameter, in feet	19·12	19	19·08	19	18	18	20	19	18	19	19	20	19
Pitch, in feet	27·52	27.5	29·27	27·5	25·5	25·5	28	28	21·67	25	28	29·42	27·25
Length in line of shaft	3·59	4·33	3·97	4·16	3·04	3·5	4·5	3·5	3·5	3·5	3·5	4·25	3·61
Immersion of lower ledge, in feet	9·08	10	10·16	7·67	10·16	11·67	9·25	11	13·25	11·67	12	11·42	14·5
Number of revolutions, per minute	54	59	57·4	59	54·8	56	45·75	52·5	61	54·5	56·5	57·66	54·66
Speed of ship, in knots per hour	12·253	12·48	12·569	12·984	11·371	11·35	11·161	11·912	11·199	11·53	11·815	12·796	11·217
Speed of propeller, in knots per hour	14·659	16·005	16·573	16·005	13·792	14·086	12·636	14·500	13·037	13·440	15·605	16·728	14·692
$Speed^3 \times Dt^{\frac{2}{3}} \div$ indicated horse-power	166·4	142·5	153·5	158·7	164·7	155·5	180·2	173·6	......	158·6	161·9	172	153·2
Wind	No. 2.	Light breeze.	Calm.	No. 2 to No. 3.	m	Light breeze.	No. 3 to No. 4.	Calm.	No. 1.	No. 6 to No. 7.	......	No. 2.	No. 2 to No. 3.
Sea	......	Smooth.	......	Smooth.	......	Smooth.	......	Smooth.	......	......	......	......	Smooth.
Remarks	......	......	......	......	......	......	......	......	......	......	......	......	......
Reference to Reports	......	......	......	.. ...	......	......	......	......	......	......	......	......	......

* Half-boiler power.

Table VII.—Men-of-War (Group 5).

Groups of a Speed	5. Between 13 and 15 knots.						
Subgroups of Displacement	F. Between 2000 and 4000 tons.				G. Between 4000 and 8000 tons.		
Names of Vessels	Newcastle.	Sutlej.	Atlas.	Duncan.	Ariadne.	Howe.	Orlando.
Length between the perpendiculars	250	254·5	244·75	252	280	260	300
Breadth (extreme)	52	51·67	55·33	58	50	61	52
Tonnage	3027	3065	3317	3716	3214	4236	3727
Mean draft of water	17·20	18·70	19·37	19·83	21·33	21·61	21·87
Area of immersed	581	530	810	808	771	949	880
Displacement	2655	2760	3940	3985	4426	4770	5416
Engines.							
Description	Horizontal.	Horizontal.	Horizontal.	Horiz. trunk.	Horizontal.	Horiz. trunk.	Horiz. trunk.
Number of cylinders	2	2	2	2	2	2	2
Diameter of cylinders	76	66	82	=82	82·06	92·5	92·5
Length of stroke	3·5	3·5	4	4	3·67	4	4
Number of revolutions, per minute	60·166	70·5	60·333	55	61·6	57·375	50
Weight per square inch on safety-valve	20	20	20	20	20	20	20
Nominal horse-power	600	500	800	800	800	1000	1000
Indicated horse-power	2452·2	2323·8	3731·5	3217·5	3350·3	4523·8	3616·6
Propeller.							
Description	....	....	....	Common, 3 blades.	....	....	....
Diameter	18	18·08	19	19·08	20	20	20
Pitch	26	20·42	27·5	27·83	25	28	32·5
Length	3·57	3·16	4·16	3·5	3·5	4·5	4·5
Immersion of centre at trial	8·67	8·01	8·08	8·92	10·57	9·25	10·25
Number of revolutions	60·166	70·5	60·333	55	61·6	57·375	50
Speed of ship, in knots	13·287	13·067	13·022	13·289	13·087	13·565	13·001
Speed of propeller, in knots	15·431	14·198	16·366	15·000	15·191	15·847	16·029
Speed$^3 \times D^{\frac{2}{3}} \div$ indicated horse-power	183·3	188·9	147·6	183·3	180·3	156·4	187·4
Wind	No. 3.	Calm.	No. 5.	Calm.	No. 2.	No. 3 to No. 4.	Light breeze.
Sea	....	....	....	....	....	Smooth.	Smooth.
Remarks	....	....	....	....	....	....	....

Table VIII.—MEN-OF-WAR of which the particulars of Boilers are given.

	Group 1. Under 7 knots.		Group 2. 7 to 9 knots.		Group 3. 9 to 11 knots.				
	St. George.	Colossus.	Chesapeake.	Bullfinch.	Renown. Half-boiler.	Lee.	Leven.	Algerine.	Slaney.
Length, in feet	206·5	194·33	207	106	244·75	125	125	125	125
Breadth, in feet	55·46	56·42	50	22	55·33	23	23	23	23
Mean draft of water, in feet	24·85	12·32	21·93	6·75	23·67	8·08	8·25	8·12	8·08
Area of immersed section, in square feet	1012·4	911	758	132	1050	150·5	154·5	151·5	150·5
Displacement, in tons	4559	3785	3402	266	5320	367	378	370	367
Engines.									
Description	Horizontal.	Hor. trunk.	Horizontal.	H.p. doub. trunk.	H. doub. acting.	Hor. H. Pr.	Hor. H. P.	Hor. H. P.	Hor. H. P.
Number of cylinders	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches	71	58·25	64	22·92	89·5 & 36	18	18	18	18
Length of stroke, in feet	3	3·25	3	1	4	1·5	1·5	1·5	1·5
Number of revolutions, per minute	46	53	....	194	43·5	154	156	158	155
Speed of piston, in feet per minute	276	344·5	....	388	342	462	468	474	465
Nominal horse-power	500	400	400	60	800	80	80	80	80
Indicated horse-power	1123	1020	897	241·48	1429	303·6	299·5	293·9	299·8
Total weight of engines, in tons	115	70	93	6·25	163	6·05	6·05	6·05	6·05
Propeller.									
Description	....	....	....	Griffiths.	....	....	....	....	....
Diameter	18	17·12	17	6	19	6·5	6·5	6·5	6·5
Pitch	20	18·46	22·5	5·57	28	7·67	7·67	7·67	7·67
Length in line of shaft	3	2·89	3	1·06	3·5	....	....	....	....
Number of blades	2	2	2	2	2	2	2	2	2
Depth of immersion from top of blade to surface of water	5·46	5·22	2·79	0·08	1·83	0·61	1·20	0·87	1·04
Boss, in feet	3·75×1·83	3·16×2	3×1·75	1·67×1·75	3·5×2	1·16×·75	1·16×·75	1·16×0·75	1·16×0·75
Weight of screw, in tons	6·6	6·95	6·55	0·30	10·75	0·612	0·612	0·612	0·612
Speed of ship, in knots per hour	4·5	6	7·2	8·534	9·145	9·270	9·270	9·30	9·350
No. of revolutions of propeller, per minute	....	....	....	194	43·5	154	156	158	155
Boilers.									
Pressure of steam in boiler, lbs. on the sq. in.	17	20	....	60	20	60	60	60	60
Description	Tubular.	Tubular.	Tubular.	Cyl. tubular.	Com. tubular.	Cyl. tubular.	Cyl. tubular.	Cyl. tubular.	Cyl. tubular.
Length, in feet	15·5	12·08	13·08	13·67	13·67	16·25	16·25	16·25	16·25
Breadth, in feet	11·33	11·75	11·5	4·33	11·25	4·67	4·67	4·67	4·67
Height, in feet	11·08	11·67	11·5	....	13	....	....	....	....
Steam-room, in cubic feet	1996	1288	1568	127	3562	131	131	131	131
Water-room, in cubic feet	2170	1680	2100	360·5	3780	446	446	446	446
Number of furnaces	20	12	16	3	24	3	3	3	3
Grate surface, in square feet	337·5	253	277	33·75	544	33	33	33	33
Total heating surface, in square feet	9449·5	6644	7387	1096·25	14854	1517	1517	1517	1517
Number of boilers	4	4	4	3	6	3	3	3	3
Weight of boilers, total, in tons	128	90	112	13·5	179·8	14·25	14·25	14·25	14·25
Weight of water in boilers, in tons	....	....	....	10·3	108	12·75	12·75	12·75	12·75

TABLE VIII. (*continued.*)

	Group 4. 11 to 13 knots.					Group 5. 13 to 15 knots.	
	Marlborough.	Flyingfish.	Renown.	Diadem.	Doris.	Orlando.	Mersey.
Length, in feet	245·5	200	244·75	240	240	300	300
Breadth, in feet	61·20	30·33	55·33	48	48	52	52
Mean draft of water, in feet	26·24	11·42	23·67	20·67	20·49	21·79	21·57
Area of immersed section, in square feet	1169	226	1050	768	732	876	865
Displacement, in tons	6035	1033	5320	3918	3716	5456	5308
Engines.							
Description	Horizontal.	Horizontal.	H. doub. acting.	Horizontal.	H. doub. acting.	H. doub. acting.	H. doub. acting.
Number of cylinders	2	2	2	2	2	2	2
Diameter of cylinders, in inches	82	58·5	89·5 & 36	82	89·5 & 36	100 & 38	92
Length of stroke, in feet	4	2·25	4	4	4	4	4
Number of revolutions per minute	54·66	79	54·5	55·25	53·71	53	55·25
Speed of piston, in feet per minute	437·33	355·4	436	442	429·68	424	442
Nominal horse-power	800	350	800	800	800	1000	1000
Indicated horse-power	3054·26	1049·68	2754·64	2685·04	3009·03	3992	4044
Total weight of engines, in tons	160	49	163	160	162	194	200
Propeller.							
Description	Maudsley.	Common.	....	Griffiths.	Griffiths.	....	....
Diameter	19	13·16	19	18	20·08	20	20
Pitch	27·25	19·96	28	13·08	30	29·75	29·42
Length in line of shaft	3·61	3·01	3·5	....	4·20	4·5	4·25
Number of blades	2	2	2	2	2	2	2
Depth of immersion from top of blade to surface of water	4·75	0·08	1·83	1·35	0·29	0	0·16
Boss, in feet	3·83×2	3×1·5	3·5×2	3·75×5	3·67×5·00	3·83×2·25	....
Weight of screw, in tons	12	3·85	10·75	10·20	11·38	12	13
Speed of ship, in knots per hour	11·217	11·536	11·43	11·899	12·158	13·16	13·290
No. of revolutions of propeller per minute	54·66	79	54·5	55·25	53·71	53	55·25
Boilers.							
Pressure of steam in boiler, lbs. on the sq. in.	20	19·5	20	18·5	20·6	19·67	20
Description	Com. tubular.	High & low tub.	Com. tubular.	Com. tubular.	Com. tubular.	Com. tubular.	Com. tubular.
Length, in feet	13·92	10·25	13·67	13·83	13·75	14·42	14·57
Breadth, in feet	11·75	10	11·25	11·61	11·25	12·25	11·5
Height, in feet	13·33	11	13	12·57	11·75	11·83	12·08
Steam-room, in cubic feet	2700·8	1528	3562	2454·4	2263	3316	3666
Water-room, in cubic feet	3920	1365	3780	3920	4620	5740	4760
Number of furnaces	24	18	24	24	24	32	32
Grate surface, in square feet	544	247	544	544	544	688	720
Total heating surface, in square feet	15166·8	7005	14854	15166·8	14749	19431	18881
Number of boilers	6	6	6	6	6	8	8
Weight of boilers, total, in tons	211·8	76·6	179·8	192·25	172	228	263·7
Weight of water in boilers, in tons	112·0	39	108	112	132	164	136

On the Meteorology of Port Louis in the Island of Mauritius. By Charles Meldrum, *M.A.*

[A communication ordered to be printed *in extenso*.]

Mauritius lies nearly between the parallels of 20° and 21° S. latitude and the meridians of 57° and 58° E. longitude. With the exception of the small islands of Réunion, Rodrigues, and the Cargados, which are from 100 to 300 miles distant, the nearest land is Madagascar, about 500 miles due west. The nearest point of Africa is about 1100 miles W. b. N., and of India about 2000 miles N.E. b. N. Towards the E.N.E., E., and E.S.E., are the Indian archipelago and Australia, at distances of 2600 to 3400 miles; while to the southward an almost unbroken ocean stretches away to the polar seas.

Thus surrounded by a great expanse of ocean, especially to windward, Mauritius may be regarded as a locality in which the meteorological elements may be determined in a form comparatively free from the complications caused by neighbouring masses of land.

The island itself, which is of volcanic origin, has an area of 700 square miles, and is of an oval form. Its greatest length is 39 miles, and its greatest breadth 34 miles. Nearly one-third of it is under the cultivation of the sugar-cane, the other two-thirds consisting chiefly of pasturage, forest, and mountain. In the interior, and more or less surrounded by three chains of mountains, varying from 1000 to nearly 3000 feet in height, and sending off spurs towards the coast, is a tableland, which attains an elevation of 800 to 1400 feet, and a considerable portion of which has of late years been planted with the sugar-cane, the primeval forests having, to a great extent, been cut down for the purpose. Between these mountain-chains and the shore, particularly in the northern parts of the island, are plains generally covered with sugar-cane, and gently sloping to the sea, above which they are but little elevated. For beauty and variety of scenery, for bold mountains, generally clothed halfway up their steep sides with evergreen trees and shrubs, and rearing their naked heads against skies of the softest blue, for rugged precipices, fantastic knolls, peaks, and ridges, for tangled forests, deep ravines and caverns, picturesque waterfalls, shady groves, and rich fertile plains and valleys, this little island is perhaps unsurpassed.

The Observatory is situated on the west side of the harbour of Port Louis, on the north-west coast of the island, in 20° 9′ 56″ S., and 57° 29′ 30″ E. It stands upon a coral-rock. From W.S.W. to E.N.E., through the east, it is surrounded by a chain of mountains rising to the height of 700 to 2707 feet. As these mountains bear in the direction from which the prevailing wind blows, and are only from a quarter of a mile to a mile and a half distant, the position of the Observatory is not very favourable.

The observations which form the basis of this communication embrace a period of seven years, namely 1860 to 1866 inclusive.

There are two classes of observations,—1st, observations taken daily at $3\frac{1}{2}$ A.M., $9\frac{1}{2}$ A.M., $3\frac{1}{2}$ P.M., and $9\frac{1}{2}$ P.M.; and, 2nd, observations taken hourly on the 21st of each month.

The former are referred to as the *six-hourly observations*, and the latter as the *term-day observations*.

As the principal use of the term-day observations is for determining the epochs of the turning-points and the range of the meteorological elements in their diurnal march, they are not, like the six-hourly observations, dis-

cussed for the whole period, but for such portions of it as have been deemed sufficient for the object in view.

The instruments are by Newman, Negretti and Zambra, and Casella, and have been compared with the Greenwich and Kew standards. The barometer, the tube of which has an interior diameter of ·564 inch, is, with the thermometers, 30 feet above the sea-level. The rain-gauge and solar thermometers are 40 feet above the ground, and the vane of Osler's anemometer 10 feet above the highest point of the building.

From 1852 to 1859 a similar series of observations was taken by the Royal Engineers, in a tower about 400 yards west of the Observatory; so that the two series embrace a period of 14 years. I confine myself to the second series (1860–66), taken under my own direction. The results are given in 42 Tables, to which I beg to prefix a few remarks, intended to direct attention to some of the more salient features. I begin with the temperature.

I. Temperature.

Diurnal Variation.—The last line but one in Table I. exhibits the mean temperature of the air at $3\frac{1}{2}$ A.M., $9\frac{1}{2}$ A.M.. $3\frac{1}{2}$ P.M., and $9\frac{1}{2}$ P.M. The means for these hours are 75°·50, 77°·59, 78°·99, and 76°·36, respectively, which gives a mean daily temperature of 77°·11. The last line shows the excess or defect of the mean for each observation hour on the mean (77°·11) of the 10,220 observations taken during the whole period of seven years.

As the intervals between the observation hours are considerable, it is necessary, in order to obtain more complete information regarding the diurnal march of the temperature, to have recourse to the hourly observations taken on the term-days. The results of these, for a period of four years, are presented in Table II., in which the last column but one gives the mean temperature for each hour, commencing with 6 A.M. We perceive that there is a single progression, having one ascending and one descending branch, the temperature gradually increasing from 75°·55 at 6 A.M. to 79°·43 at 1 P.M., and then decreasing till 6 A.M. This progression, it need scarcely be remarked, is dependent on the earth's rotation on its axis with regard to the sun. In the last column is presented the amount by which the mean for each hour falls short of (−), or exceeds (+), the mean for the 24 hours (77°·14). We see that there are nine hours, namely, 10 A.M. to 6 P.M. inclusive, during which the temperature is above the mean for the day, and fifteen hours during which it is below the mean. The range is 3°·88. The greatest increase in any two hours takes place between 9 and 11 A.M., and amounts to 1°·81, and the greatest fall in any two hours from 3 to 5 P.M., and amounts to 1°. The mean temperature for the day occurs very nearly at 9 A.M. and 7 P.M.

On inspecting the other columns, which give the diurnal variation for each month, it may be seen that, though the minimum generally occurs at 6 A.M., and the maximum at 1 P.M., the epochs of the turning-points vary a little with the season.

Comparing Tables I. and II., we find that the mean daily temperature is almost identical in both, being 77°·11 in the one, and 77°·14 in the other, notwithstanding the fewness of the observations in the latter case.

Greatest Diurnal Range.—Table III. shows the greatest range of temperature, on any one day, in each month, obtained from daily observations of the maximum and minimum thermometers for five years (1862–1866). It will be seen that the greatest range on any one day during that period was

13°, in March 1866, and the least of the extreme diurnal ranges 6°·4, in October and November 1862, and that the greatest variations of temperature take place during the summer months, namely, from November to May.

Least Diurnal Range.—The least range of temperature, on any one day, during the same five years, was 1°·4 in June 1866, and the greatest of the least diurnal ranges 6° in January 1865, as appears from Table IV., which likewise shows that the summer months are subject to greater fluctuations of temperature than the winter months.

Mean Diurnal Range.—Table V., in which the mean diurnal range for each month is given, shows that the mean diurnal range for the year is 6°·69, and that the greatest fluctuations occur in the summer months.

Annual Variation.—The annual march of the temperature, derived from the daily six-hourly observations for seven years, is exhibited in the last column but one of Table VI. Like the diurnal march it is a simple progression, having one ascending and one descending branch. The least mean monthly temperature is 71°·95 for July, and the greatest 81°·72 for January. From July to January the temperature increases, and from January to July it decreases. This progression, as is well known, depends on the motion of the earth in its orbit. The epochs of highest and lowest temperature, however, do not coincide with those of the sun's highest and lowest meridional altitudes, but occur at later periods, the maximum temperature about the 4th of February, and the minimum about the 7th of August. The last column shows the amount of variation, or the excess and defect of the mean temperature (77°·11) on the monthly means. During the six summer months the temperature is above, and during the six winter months below, the mean temperature, the epochs of which are the 7th of May and the 5th of November.

For the sake of comparison, I have given in Table VII. the mean monthly temperature obtained by taking the mean of the daily readings of the maximum and minimum thermometers. The mean annual temperature thus derived is 77°·80, or 0·69 higher than that given by the six-hourly observations.

Temperature in the Sun's Rays.—Table VIII. shows the mean monthly maximum temperature in the sun's rays, obtained by daily observation of a black bulb thermometer inclosed in an exhausted tube, exposed at an elevation of 40 feet above the ground, and protected, as far as possible, from local radiation. The results, which, as measures of solar radiation, are, of course, subject to the usual objections, present a progression similar to that of the temperature in the shade, the greatest mean monthly maximum being 117°·6 for January, and the least 101°·2 for July,—the progression being harmonious, except that the temperature in February is somewhat lower than in March, owing probably to the former month being cloudier than the latter.

Extreme Monthly Range.—Table IX. shows the maximum and minimum temperature and the extreme range of temperature for each month, and their monthly and yearly means. The greatest range in any one month was 18° in November 1864, and the least 6°·4 in October 1862. The greatest fluctuations occur in the warmest months.

Secular Variation.—The last line in Table VI. shows that the temperature has varied little, it being for four years out of the seven almost the same, and the greatest difference between any two years being only 0°·95.

A similar remark applies to the numbers in the last line in Table VII., showing the mean annual temperature as derived from the self-registering thermometers.

The last line in Table VIII. shows that the temperature in the sun's rays was considerably greater in 1860 than in any other year, and that, upon the whole, it decreased till 1864, and has been increasing since that year.

Extreme Annual Range.—The extreme annual range of temperature for each year is given in Table X., containing the highest and lowest readings of the self-registering thermometers, and the epochs of occurrence. The mean annual range is 22°·52.

II. Elastic Force of Vapour.

The pressure of the atmosphere, as measured by the barometer, is the combined pressures of the dry air and the aqueous vapour suspended in it; and many are of opinion that, by means of simultaneous observations of the barometer and dry and wet thermometers, the two pressures may be separated and exhibited apart.

Diurnal Variation.—The last line but one in Table XI. gives the diurnal march of the vapour-pressure in inches of mercury, as deduced by Glaisher's Tables from the six-hourly observations of the dry and wet thermometers. We perceive that the pressure is greatest (·658) at the warmest observation hour ($3\frac{1}{2}$ P.M.), and least (·646) at the coldest hour ($3\frac{1}{2}$ A.M.), which is what would be expected, since the capacity of air for vapour is directly as the temperature. The last line shows the amount of variation, which is slight.

The last two columns in Table XII. exhibit the mean vapour-pressure for each hour of the day, and its deviation from the daily mean, obtained from the hourly term-day observations for four years (1863–66). Here we have complete evidence of a direct harmony between the diurnal march of the vapour-pressure and that of the temperature, the hours of the greatest vapour-pressure coinciding with those of the greatest temperature, and *vice versâ*. We see that the march of the vapour-pressure, though a little irregular, is like the march of the temperature, a single progression, having two branches, the one, upon the whole, ascending from 4 A.M., when the pressure is least (·621), to 1 P.M., when it is greatest (·646), and the other descending from 2 P.M. to 4 A.M. Between 6 and 8 A.M., as the heat increases, the pressure takes a start upwards, and from 8 A.M. to 3 P.M. it is nearly stationary. From 3 to 4 P.M., as the heat declines, the vapour-pressure also declines, and again continues nearly uniform till 2 A.M., between which hour and 4 A.M. it falls once more. From 8 A.M. to 5 P.M. it is above the mean for the day, and from 5 P.M. to 8 A.M. below it, attaining its mean value about 7 A.M. and 5 P.M.

Annual Variation.—The last two columns in Table XIII. give the annual march of the vapour-pressure, and the amount of its deviation from the annual mean, derived from the six-hourly observations. Here also we have, upon the whole, a single progression. The vapour-pressure attains its maximum (·767) in February, and its minimum (·550) in July. From February to July it decreases, and from July to February it increases, except in September, when it is less than in August,—August, as we shall presently see, being a month in which not only the vapour-pressure, but also the humidity, rainfall, and cloud are greater than in the months immediately preceding and following it, these elements showing a tendency to a small second maximum. During the six summer months the vapour-pressure exceeds the mean for the year (·652), and during the six winter months it falls short of it. There is thus a connexion between the annual variation of the vapour-pressure and that of the temperature of a kind similar to that between the diurnal variations of the same elements, the progressions being in the same direction, and the turning-points nearly coincident.

Extreme Monthly Range.—From Table XIV., which gives the maximum and minimum vapour-pressure and the range for each month, together with their monthly means, it will be seen that the greatest range in any one month was ·384 in March 1864, and the least ·149 in May 1863 and September 1864, and that January to May inclusive are the months subject to the greatest fluctuation.

Secular Variation.—An examination of the last two lines in Table XIII. will show that, upon the whole, the vapour-pressure has been decreasing since 1860. This becomes more evident when we take the means of the results for every two consecutive years. The mean pressure for 1866 was ·033 below the mean for the seven years, and ·061 below the mean for 1860. Looking at the columns which give the monthly means in each year, we find that the greatest mean monthly pressure was ·792 in February 1860, and the least ·498 in July 1866.

Extreme Annual Range.—Table XV. gives the greatest and least vapour-pressure and the range for each year, with the dates. The mean annual range is ·494 inch.

III. Humidity.

The degree of humidity is the ratio of the amount of vapour contained in the air to the amount it would contain if saturated with vapour. Hence, if complete saturation be denoted by 100, and complete dryness by 0, the degree of humidity at any temperature will be obtained by multiplying the actual tension of vapour at that temperature by 100, and dividing the product by the tension required for complete saturation at the same temperature.

Diurnal Variation.—Table XVI. gives the diurnal variation of the relative humidity, so far as it can be directly determined by six-hourly observations. An inspection of the last line but one will show that the humidity is least (67·3) at the warmest observation hour ($3\frac{1}{2}$ P.M.), and greatest (73·7) at the coldest observation hour ($3\frac{1}{2}$ A.M.), and that at the other hours it has intermediate values. The mean relative humidity is 70·9, or, complete saturation being 100, nearly 71 hundredths.

Table XVIII., in which the hourly means of the relative humidity, and their deviation from the daily mean, are given, as obtained from four years' term-day observations, shows that the diurnal march, like that of the temperature and vapour-pressure, is a single progression, with two branches and two turning-points. In this case, however, the march is in a contrary direction, the greatest humidity occurring at the coldest hours of the day, and the least at the warmest. Thus, the least humidity (63·6) occurs at 1 P.M., from which hour till 2 A.M. it increases to 69·9. It then remains nearly stationary till 8 A.M., showing, however, a tendency to a second minimum at 4 A.M. From 8 A.M. to 1 P.M. it decreases. From 9 A.M. to 7 P.M. it is below the mean for the day, and during the other hours above it, attaining its mean daily value about 9 A.M. and 7 P.M.

Annual Variation.—The annual march of the relative humidity, and its variation, are shown in the last two columns of Table XVIII. Here we see that February is the most humid month, and November the driest, the mean for the former being 74·7, and for the latter 68·1. From February to June the humidity decreases; from June to August it increases; from August to November it decreases again, and from November to February increases. There are thus two maxima and two minima, the February

maximum, however, being considerably greater than the August maximum, and the November minimum considerably less than the June minimum.

We have seen that the diurnal march of the humidity corresponds with that of the temperature in an inverse sense, the coldest hours being the moistest, and the warmest hours the driest. Such is not the case with the annual march, for the most humid months are the warmest. This seems to arise from the greater length of time that the high temperature prevails in the one case than in the other. From August (which is nearly the coldest month) to November, the humidity goes on decreasing with an increasing temperature, the relation between the two elements in their annual march being here analogous to that between them in their diurnal march; but it would appear that by December the vapour has accumulated so much that, notwithstanding the increasing temperature, the humidity, instead of decreasing further, begins to increase, and it goes on increasing till February. Owing to the excess of accumulated vapour, time is now required to restore the two elements to their normal relation; and although the temperature decreases, the humidity does not increase but decreases, the evaporation from the surrounding ocean becoming less active; and it is not till June that the humidity begins to increase with a decreasing temperature. In August the temperature commences to rise, and then the humidity decreases with the increasing temperature till November or December, when the overpowering effect of evaporation again causes the humidity to increase with the temperature.

Extreme Monthly Range.—Table XIX. gives the highest and lowest humidity and the extreme range for each month. The greatest range for any one month was 38·7 in January 1860, and the least 17·5 in November 1866. January, February, March, and August are the months in which the greatest fluctuations occur.

Secular Variation.—The last two lines in Table XVIII. show that 1860 was the most humid year (73·6), and 1866 the driest (66·4); and that, upon the whole, the humidity, like the vapour-pressure, has been decreasing since 1860. The most humid month during the seven years was August 1860 (77·8), and the driest November 1866 (57·0), when a severe drought prevailed.

Extreme Annual Range.—Table XX. shows the maximum and minimum relative humidity, the epochs, and range for each year. The mean annual range is 41·5.

IV. Atmospheric Pressure.

Diurnal Variation.—Table XXI. exhibits the mean pressure of the atmosphere for each of the hours $3\frac{1}{2}$ A.M., $9\frac{1}{2}$ A.M., $3\frac{1}{2}$ P.M., and $9\frac{1}{2}$ P.M.; and whether we regard the monthly results, or the yearly results, for those hours, we find two maxima and two minima, the maxima occurring at $9\frac{1}{2}$ A.M. and P.M., and the minima at $3\frac{1}{2}$ A.M. and P.M. From the last line but one it appears that from $3\frac{1}{2}$ A.M. to $9\frac{1}{2}$ A.M. the barometer rises from 30·038 to 30·086 inches, which gives a range of ·048 inch; from $9\frac{1}{2}$ A.M. to $3\frac{1}{2}$ P.M. it falls from 30·086 to 30·015, that is, to the extent of ·071; from $3\frac{1}{2}$ P.M. to $9\frac{1}{2}$ P.M. it rises from 30·015 to 30·085, or to the extent of ·070; and from $9\frac{1}{2}$ P.M. to $3\frac{1}{2}$ A.M. it falls to the extent of ·047.

But in order to know with certainty whether the march is a double progression, and, if so, what are the epochs of the turning-points, we must examine the term-day observations. The results of these for four years are presented in Table XXII. The last two columns exhibit the mean atmospheric

pressure for each hour of the day, and its deviation from the mean of all the observations. Beginning with 9 A.M., we find that for that hour the mean height of the barometer is 30·090 inches. It then gradually falls to 30·017 at 3 P.M., from which hour it ascends till 10 P.M., when it stands at 30·086. It again gradually falls to 30·037 at 4 A.M., from which hour it again rises till 9 A.M. We thus see that the diurnal march of the atmospheric pressure is a double progression with four turning-points, namely, two maxima at 9 A.M. and 10 P.M., and two minima at 4 A.M. and 3 P.M.

This diurnal oscillation of the atmospheric pressure at Mauritius, as at other tropical stations, is extremely systematic and regular. Its amount, and the epochs of its turning-points, vary a little according to the time of year, as may be seen from the Table; but, except on very rare occasions, as on the 13th of January 1863, when the centre of a revolving storm was passing near the Observatory, it makes its appearance unerringly in all kinds of weather. Several theories have been framed with the view of explaining it, but none of them has met with entire acceptance.

Annual Variation.—In the last two columns of Table XXIII. we have the annual march of the atmospheric pressure, and the monthly deviation from the mean for the year. We perceive that the mean pressure for February is 29·843 inches, that from February to August it gradually increases to 30·193, and then gradually decreases till February, and that thus the progression is single, having one maximum and one minimum. The annual march of this element, therefore, is in a contrary direction to that of the temperature, the maximum of the one corresponding nearly, but not exactly, with the minimum of the other, and *vice versâ*, the turning-points of the atmospheric pressure occurring later than those of the temperature. From December to April inclusive, the barometer is below its mean for the year (30·056), and during the other months above it, the epochs of the mean being about the 11th of May and the 9th of November.

Extreme Monthly Range.—Table XXIV. gives the maximum and minimum pressure and the range for each month, with their means. The greatest range in any one month was 0·977 inch in February 1861, and the least ·170 inch in December 1860. December, January, February, March, and June are the months in which the greatest fluctuations occur.

Comparing the mean monthly oscillation of the atmospheric pressure given in this Table with that of the vapour-pressure in Table XIV., we find that, if the oscillations of the vapour-pressure affect the barometer to their full extent, the barometric oscillations depend more upon those of the vapour-pressure than of the dry pressure.

Secular Variation.—On looking over the last line in Table XXIII., showing the annual means, we find that since 1861 the atmospheric pressure has been increasing. The lowest annual mean is 30·032 for that year, and the highest 30·081 for 1864 and 1866, which gives a range of ·049 inch, an amount no doubt mainly due to the disturbing effect of hurricanes. Owing to the great prevalence of hurricane weather in February 1861, for example, the mean for that month (29·665) is less than it would otherwise have been, and consequently that for the year.

Extreme Annual Range.—Table XXV. gives the greatest and least pressure, the epochs, and range for each year. The mean annual range is 0·918 inch, while that of the vapour-pressure (Table XV.) is 0·494 inch.

V. Pressure of the Dry Air.

The phenomenon of the double maximum and minimum, exhibited by the

diurnal march of the total atmospheric pressure, has received from M. Dove, and, after him, from General Sabine, Sir John Herschel, and others, an explanation founded on the supposed effect of one of the constituents of the total pressure, namely, the aqueous pressure. Assuming that observations of the wet and dry thermometers enable us to determine the whole pressure of the vapour in the atmosphere, and finding in many instances that when the vapour-pressure thus obtained is deducted from the total pressure, the march of the residual dry pressure presents a single progression, having one maximum and one minimum, corresponding with the coldest and hottest hours, it has been inferred that the double maximum and minimum of the total pressure is owing to the march of the vapour-pressure being contrary to that of the gaseous pressure, an increase of temperature causing an increase of vapour-pressure, but a decrease of dry pressure, and *vice versâ.*

Let us see whether this view will afford an explanation of the double maximum and minimum of the total pressure at Mauritius.

Diurnal Variation.—In Table XXXVIII. will be found the total atmospheric pressure, the vapour-pressure, and the dry pressure for each hour, derived from the term-day observations; and it will be seen that the dry pressure does not present a single progression, but, like the total pressure, a well-marked double progression, having two maxima at 9 A.M. and 10 P.M., and two minima at 3 P.M. and 3 A.M.

The hourly observations from which these results have been deduced were not numerous, but there is little doubt that more extensive observation would have led to the same conclusion; for the six-hourly observations, extending over a period of seven years, also give a double maximum and minimum for the dry pressure, as will appear from an inspection of Table XXXVII., which shows that the dry pressure has a maximum at 9½ A.M. and P.M., and a minimum at 3½ A.M. and P.M., just like the total pressure.

We are thus led to conclude that, if the observations of the dry and wet thermometers afford the means of determining the vapour-pressure, the gaseous pressure at Mauritius has a progression in every respect similar to that of the total atmospheric pressure, and therefore that the phenomenon in question cannot be accounted for by the direct action of the vapour-pressure.

A similar progression of the dry pressure at Bombay has been referred to the relations which arise from the juxtaposition of land and sea, causing land and sea breezes. At Mauritius, surrounded on all sides by the Indian Ocean, the double progression of the dry pressure occurs in all kinds of weather, and from whatever quarter the wind may come, and is most marked on those days when the trade-wind blows steadily; and hence it is presumable that it occurs at sea, away from the influence of land.

Annual Variation.—At many extratropical stations, the annual variation of the total pressure shows little trace of periodicity, but when the vapour-pressure is deducted, the dry pressure is found to have a progression in inverse harmony with that of the temperature. On examining Table XXXIX., it will be seen that at Mauritius the annual march of the dry pressure is exactly like that of the total pressure, and that both have apparently the same relation to the temperature.

VI. Direction and Veering of the Wind.

Table XXVI. shows the number of times the wind blew from the principal points of the compass. The observations were taken four times a day during

five years, and their number therefore was 7300, of which 1076 were for calms, and 98 for variables, leaving 6126 for the direction of the wind. The distribution of this latter number for the four quarters of the horizon was as follows: from north to east (not including east) 683, from east to south (not including south) 4740, from south to west (not including west) 158, and from west to north (not including north) 545,—showing that the number of times the wind came from the points between east and south was nearly four times as great as the number of times it came from the remaining three quarters together. From east to S.E. inclusive, the number of observations was 4286, which is more than two-thirds of the total number of observations. This shows the great preponderance of the trade-wind, which prevails throughout the whole year, but is strongest and steadiest from May to November, and more especially in June, July, and August.

The wind veers almost always with the sun, or from S.E. through east to north, N.W., &c., decreasing in force as it veers. It often remains steady at E.S.E. for a week or ten days. After it passes N.E., calms and variables with light north-westerly and westerly breezes, and close sultry weather prevail for two or three days. The trade-wind then reappears at S.S.E. A similar revolution sometimes takes place in the course of a day. The wind seldom veers in the opposite direction; but it always does so during the passage of a revolving storm on the east side of the island.

VII. Force of the Wind.

Diurnal Variation.—As Osler's anemometer is not affected by light breezes, the force of the wind at the observation hours has usually been estimated. Table XXVII. gives the mean estimated force derived from the six-hourly observations. The results are but approximations; for, independently of other sources of error, the site of the Observatory is not favourable for determining the true force and direction of the wind, even with the most approved instruments. Still, the observations indicate that the force varies directly as the temperature, the greatest pressure occurring at the warmest hours.

The last column in Table XXXVIII. gives the mean estimated force for each hour derived from the term-day observations. Here likewise, notwithstanding the fewness of the observations, we see a general agreement between the variations of the force of the wind and the temperature.

Annual Variation.—Table XXVIII. gives the mean estimated force. January, February, and March are the months in which the wind is strongest at the observation hours, and next to them June, July, and August. In the former months hurricanes occur, and in the latter the S.E. trade-wind blows in full force. From February to May the wind decreases; in June, July, and August it is high; from August to November it decreases, and from November to February it increases. There is thus an indication of a double progression.

Mean Monthly Maximum Force.—Table XXIX. shows the mean maximum force of the wind for each month, as recorded by Osler's anemometer, without regard to the hour of the day. We find that, notwithstanding the severe hurricanes which occasionally occur in the summer months, the mean maximum force of the wind is greater for June, July, and August than for any other three months. We perceive also that this Table, like the former, points to a double maximum and minimum. From November to February the wind increases with an increasing temperature, and from February to April it de-

creases with a decreasing temperature. But from April to June it again increases with a decreasing temperature, and stands high in the latter month, and in July and August, owing probably to the high temperature in the northern hemisphere causing an influx of air (S.W. monsoon) towards the heated regions, and thus exciting the S.E. trade-wind in the southern hemisphere. From August to November the mean maximum force decreases.

Secular Variation.—The last lines in Tables XXVIII. and XXIX. show that 1860, 1861, and 1863 were the years in which the force of the wind was greatest, and we shall presently see that these were the years in which hurricanes were most frequent and violent. The years 1862 and 1864 were remarkable for an absence of hurricanes, and these were the years in which the mean force of the wind was least.

Extreme Annual Force.—Table XXX. shows the greatest force of the wind, and the epoch, for each year.

VIII. Cloud.

Tables XXXI. and XXXII. exhibit the mean amount of cloud for each of the four daily observation hours, each month and each year. The nights and mornings are comparatively cloudless. Towards 10 A.M. the clouds begin to gather, by 2 P.M. the sky is often overcast, and in the evening the weather usually clears up. The mean amount of cloud for the year is 47, 100 denoting completely overcast. February is the cloudiest and June the least cloudy month, the means being 59 and 40 respectively. The last column in Table XXXII. points to a connexion between the amount of cloud and the temperature. From November to February the amount of cloud increases, and from February to June it decreases. From June to November, however, there is a tendency to a second progression.

IX. Rainfall.

Table XXXIII. gives the amount of rainfall for each month and year. The greatest fall in any one month during the seven years was 46·57 inches in February 1861. In September 1861 and November 1866 there was no rainfall sufficient to affect the gauge. The greatest mean monthly fall is 14·23 inches for February, and the least 0·39 inch for September. From September to February the rainfall increases; from February to June it decreases; from June to August it increases again, and then falls in September,—showing, upon the whole, a double progression, having its maxima in February and August, and its minima in June and September. The mean annual fall is 37·87 inches, and the mean monthly fall 3·16 inches. The greatest fall in any one year was 68·76 inches in 1861. and the least 20·56 inches in 1866. The principal rain-bearing wind is the trade-wind from E.S.E. to E.N.E.; but at times, during the summer months, torrents of rain descend with northerly and north-westerly winds, and on those occasions the mountains become enveloped in dense mist. The greatest rainfall on any one day, in each year, with the date, is shown in Table XXXIV.

There is reason to fear that the rainfall is decreasing: the fall during the first three years was considerably greater than that during the last four years of the period of seven years.

In some parts of the island the rainfall is much greater than at Port Louis, as will be seen from Table XXXV., showing the rainfall at nineteen stations for periods ranging from two to five years. Of these stations, Gros Cailloux and Port Louis, both on the coast, and not many feet above the sea-level, are

the furthest west, and it is at them that the rainfall is least, the mean annual amount for five years being 28·03 inches at the former, and 30·24 inches at the latter station. Mont Choisy is also on the west coast near the northern extremity of the island, but further east than Gros Cailloux and Port Louis, and at it the mean annual fall for the same period was 51·54 inches. Some miles south-eastward of Mont Choisy, further from the coast, and at elevations of 200 to 600 feet, are four other stations, namely, Les Rochers, Labourdonnais, the Botanical Gardens, and Lucia; and, with the exception of Les Rochers, where the mean annual fall was 50·10 inches, the rainfall at each of these stations was considerably greater than at Mont Choisy, having been 63·62 inches at Labourdonnais, and 67·98 inches at Lucia; while at the Botanical Gardens, in 1864 and 1865, it was also greater than at Mont Choisy. It should here be remarked that Lucia, the station at which the greatest rainfall occurs in that part of the island, lies south-eastward of the other stations, and at a higher elevation. About fourteen miles due north of Lucia is a small island, called Flat Island, about five miles from the mainland. Observations on the rainfall were taken there in 1862 and 1863, and it will be seen that the amounts for those years were 28·02 and 36·54 inches, respectively, or nearly the same as at Port Louis. About seven miles S.S.W. of Lucia, and at the same distance E.S.E. of Port Louis, is Espérance, on the central tableland, at an elevation of about 1400 feet. Here, in 1865, the rainfall was 147·74 inches against 101·56 at Lucia, 44·73 at Port Louis, and 36·57 at Gros Cailloux. Westward and south-westward of Espérance, at distances of five to eleven miles, and at elevations of 900 to 1300 feet, are five stations more, namely, Croft-an-Righ, Beau Sejour, Trianon, the Braes, and Mesnil, at each of which the rainfall, though more than double what it is at Port Louis, is considerably less than at Espérance. At a distance of about eight miles east of Espérance, and about four miles from the east coast, is La Gaité. Here the rainfall is also less than at Espérance, but greater than at the stations westward and south-westward of it (except Mesnil, the highest of them), although these are more elevated than La Gaité. But the rainiest station of all is Cluny, which lies about eleven miles south of Espérance, and sixteen miles S.E. of Port Louis, at a height of about 900 feet above the sea, and nearly surrounded by mountains and forests. At this station, in 1865, the rainfall was 192·45 inches, and the mean fall for five years was 142·80 inches. Southward and south-eastward of Cluny, nearer the coast, and at lower elevations, are three more stations, namely, Gros Bois, Beau Vallon, and St. Aubin, at each of which the rainfall is also very considerable, having, in 1865, been 135·21, 100·85, and 115·61 inches, respectively.

These observations illustrate the influence of local circumstances, as elevation, direction of wind, mountain, and forest on the rainfall of a place. Thus, at La Gaité, near the east coast, the rainfall (in 1865) was 97·55 inches; at Espérance, nearly due west, but at a much higher elevation, it was 147·74 inches; at Croft-an-Righ, westward of Espérance, and at a lower level than it, but at a considerably higher level than La Gaité, the rainfall was 79·44 inches; and at Gros Cailloux, west of Croft-an-Righ, on the west coast, it was only 36·57 inches, or not much more than one-third the rainfall at La Gaité on the east coast. These stations are situated nearly in a line and in the direction of the prevailing wind; and the greater fall at Espérance than at La Gaité is probably due to the higher elevation and lower temperature of the former; while the greater fall at La Gaité than at Croft-an-Righ, though the latter stands at a higher level, seems to be due to the situation of La Gaité on that side of the island on which the vapour first impinges

as it comes up from the sea. Comparing the rainfall at Beau Vallon, Cluny, Beau Sejour, and Gros Cailloux, which lie nearly in a S.E. and N.W. direction, we find similar relations.

For some years past many parts of the island, particularly on the western and northern coasts, have been suffering from drought; the rivers have been gradually diminishing, and the lakes and marshes in the interior been drying up. As we have already seen, last year (1866) has been the driest of all, the rainfall in some places having been little more than half the average fall. The consequence is that this year's crop will be very much reduced.

The evil which is thus pressing on the colony is generally attributed to the extensive clearings which have been carried on in all directions during the last fifteen years. The primeval forests with which this little island was at one time clothed have to a great extent been replaced by the sugar-cane, and now the cane languishes and dies for want of moisture. It would be satisfactory to those interested in the welfare of Mauritius to have the opinions of men of science as to the probable effect of the destruction of forests on the rainfall and humidity, and I am glad of having an opportunity of bringing the subject before the Association. Given a small mountainous island in the trade-wind region, covered with dense forests, and surrounded by a tropical sea: what effect, if any, with respect to rainfall and humidity, would be produced by stripping that island of its forests, and exposing soil and rocks to the sun's rays? It seems to me that, whether the annual rainfall would diminish or not, the air would become drier, as the greater portion of the rains would be speedily carried away to the sea, and the remaining portion speedily evaporated. This last year, however, shows a very marked decrease of rain, and if the previous six years do not so to the same extent, they show a tendency to a recurrence of floods and droughts—that is, to a disturbance in the distribution of the rainfall. The humidity of the air also has, as we have seen, been upon the whole decreasing at Port Louis since 1860. In that year it was 73·6, while in 1866 it was only 66·4.

X. Thunder and Lightning.

Table XXXVI. shows that in the course of the seven years no lightning was seen between May and November, except on one day in August 1864. January, March, February, and April are the months in which thunder-storms prevail; they generally occur in the afternoon, but occasionally at other periods of the day, or in the night. Some are local, and others travel over a considerable extent of ocean. The average number of days per annum on which lightning was visible is 26·4. The greatest number of days in any one year on which lightning was observed was 40 in 1863, and the least 19 in 1862.

XI. Gales and Hurricanes.

Mauritius, as is well known, is subject to hurricanes. The hurricane months are December to April inclusive, but more especially January, February, and March, particularly February. Strong gales occur also in June, July, and August. I will present a few of the leading facts connected with the gales and hurricanes which took place during the period under review.

1860.—Four gales occurred in 1860. The first took place between the 11th and 17th of January. The barometer fell to 29·680 inches. The wind veered from S.E. to S., S.W., and W., and attained a maximum pressure of 10 lbs. on the square foot. The rainfall was 7 inches. This was a

great revolving storm, the centre of which passed on the east side of the island, at a nearest distance of 129 miles.

Another gale took place between the 22nd and 27th of February. The barometer fell to 29·660. On this occasion the wind veered from S.E. to E., N., and N.W., and had a maximum force of 9 lbs. The rainfall was 7·455 inches. This was another revolving storm, which, as shown by the veering of the wind, passed the island on its north and west sides. The nearest distance of the centre was 220 miles.

The next gale occurred between the 18th and 27th of March. The lowest reading of the barometer was 29·464. The wind veered from S.E. to S., S.W., W., and N.W., and exerted a maximum force of 13 lbs. on the square foot. The rainfall was 4·075 inches. This was another revolving storm, which, like the first, passed on the east and south sides of the island. The nearest distance of the centre was 170 miles.

A fourth gale took place on the 21st of June, with the barometer standing at 30·252 to 30·314. The wind was from south to S.S.E., and blew with a maximum force of 18 lbs. There was no rain. This was not a revolving storm, but one of the winter gales, in which the wind veers very little, and which are apparently the immediate effect of the trade-wind being put in violent motion by the same causes that produce the S.W. monsoon of the Bay of Bengal, which the S.E. trade-wind supplies with air.

1861.—In February 1861 a hurricane occurred which lasted six days, namely, from the 11th to the 17th. It was a revolving one. For three days it remained nearly stationary, its centre bearing about 110 miles N.N.E. of the Observatory. The wind blew in fearful gusts, attended with torrents of rain, from S.S.E. to E.S.E., for five days, and then veered to E., N.E., N.W., and W. The barometer fell to 29·009 on the morning of the 16th, the centre of the storm at that time bearing N.W. 50 miles, which was its nearest distance. In the night of the 13th, the vane of Osler's anemometer was blown away, the pressure being then about 30 lbs.; the greatest pressure afterwards cannot have been less than 40 lbs. From 9½ A.M. on the 11th to 9½ A.M. on the 17th, 44·730 inches of rain fell at the Observatory, and at Vacoas, 13 miles to the southward, at an elevation of 1200 feet, 99 inches fell in the same time. The centre of the storm passed between Mauritius and the neighbouring island of Réunion.

Another severe hurricane took place from the 7th to the 16th of February, in the space between 10° and 20° S. and 76° and 84° E.; so that two hurricanes raged at the same time.

A third severe hurricane, but of much shorter duration, took place on the 2nd and 3rd of March. The wind veered from S.E. to S., S.W., and W., and blew with a maximum force of about 36 lbs. The barometer fell to 29·282, the centre of the storm, which was a rotatory one, being then 140 miles E.S.E. of the Observatory. This hurricane passed on the east side of the island.

1862.—This was comparatively a tranquil year at Mauritius, only two gales having occurred, neither of which was violent. The first took place on the 26th of February. The wind was from S.S.E. to E., and attained a maximum force of 12·50 lbs. The barometer fell to 29·888. The weather at Port Louis, except on the 26th, when it was overcast and showery, was fine; but away to the north-eastward, between 8° to 16° S. and 60° to 110° E., the S.E. trade-wind and N.W. monsoon were in stormy collision, and two severe hurricanes were encountered in that locality, both raging on the same days.

The next gale in the course of this year was experienced on the 1st and

2nd of December. The wind veered from S.E. to S., S.W., and W., and its maximum force was 9·50 lbs. The rainfall was only 0·430 inch. The barometer fell to 29·666. This was a small revolving storm, which passed on the east side of the island. Its nearest distance was 150 miles.

1863.—Several hurricanes occurred in 1863. The first took place on the 13th of January. The wind veered from E. b. S. to N.E., N., N.W., W., and W.S.W., and its maximum force was 17 lbs. The rainfall, from 9½ A.M. on the 11th to 9½ A.M. on the 14th, was 7·225 inches. This was a rotatory storm, which came down from the north-westward, and the centre of which passed over the S.W. extremity of the island. The barometer fell to 29·332.

A second gale took place between the 31st of January and the 4th of February. The wind veered from E.S.E. to N.E., N., and N.W., and attained a force of 12 lbs. The barometer fell to 29·700. The rainfall was 1·681 inch. This was another revolving storm, which passed about 50 miles west of Réunion, and caused great loss in that island.

A third revolving storm passed on the northward and north-westward of the island between the 9th and 13th of February. Its nearest distance was 200 miles. The barometer at the Observatory fell to 29·816. The wind veered from S.E. to E. and N.E., and attained a force of 14 lbs. The rainfall was 3·192 inches.

Between the 18th and 22nd of February a fourth rotatory storm of great violence passed on the north and west of the island, the wind veering from S.E. to E. and N.N.E., and attaining a maximum force of 36 lbs. The nearest distance of the centre was 50 miles. The barometer fell to 29·438. The rainfall was 2·430 inches.

1864.—The year 1864 was remarkable for an absence of hurricanes. The strongest gale took place on the 2nd of July, with the barometer at 30·209. The wind blew from S.E. to E., with a maximum force of 8·7 lbs. Scarcely any rain fell.

1865.—This year was also characterised by an absence of hurricanes. One or two gales, however, occurred in February. On the 12th of that month the wind, which had been previously veering from S.E. to E., suddenly increased from N.E. by E., and attained a force of 7·5 lbs. at 3·15 P.M., and then died away to light airs till midnight, when it increased to a force of 3 lbs. from N.W. When the wind came round to N. and N.W., the mountains became speedily enveloped in dense masses of vapour down to their bases, and between 7 and 9 P.M., during a thunder-storm, rain fell in torrents. The streams rose rapidly; bridges and causeways were swept away, stores inundated, and several lives lost. The rainfall at Port Louis in 24 hours was 7·460 inches, the greater portion of which fell between 6 and 9 P.M.; but at La Gaité it was 18·307 inches, and at Croft-an-Righ 14·65 inches. The barometer fell to 29·507. There was no revolving storm in the neighbourhood of the island on this occasion; but the N.W. monsoon advanced to the southward, and heavy rains, accompanied with strong winds, thunder, and lightning, fell in the localities where it came into collision with the S.E. trade-wind.

The strongest gale during this year took place between the 19th and 22nd of February. The wind remained at S.S.E. to E.S.E., and its maximum force was 13·5 lbs. The rainfall was only 0·665 inch. The barometer fell to 29·730. On this occasion two or three revolving storms occurred at some distance to the northward and north-eastward of the island, between the confines of the N.W. monsoon and S.E. trade-wind.

the 13th and 20th of April. The wind remained at S.E. to E.S.E. and E. throughout, and in the gusts blew with a force varying from 1 to 13·5 lbs on the square foot. The barometer ranged from 30·174 to 29·944, and oscillated during the gusts. Very little rain fell. On the 21st the wind veered to the north of east and fell light. It was afterwards ascertained that several revolving storms occurred from the 6th to the 25th of April, between the inner borders of the monsoon and trade-wind, away to the northward and north-eastward of Mauritius.

This is not the time to enter into a discussion regarding the nature and origin of these storms: I will only remark that, by watching the barometer, the wind, and the clouds, their existence and approach may be known with certainty, even when the distance is very considerable.

XII. Synopsis of Results.

With a view of facilitating a comparison of the results, I have prepared a few Tables in which the diurnal, monthly, and annual means of the principal elements are placed side by side.

Diurnal Variation.—Table XXXVII. exhibits the means for each observation hour of the six-hourly series, derived from seven years' observation; and Table XXXVIII. those for each hour of the day, derived from term-day observations taken for four years. As already remarked, the diurnal march of the temperature, vapour-pressure, force of wind, and amount of cloud are all more or less accordant, being in the same sense, and having the turning-points nearly at the same hours. The diurnal march of the humidity is in a contrary sense, but the turning-points are nearly coincident with those of the temperature. With regard to the total atmospheric pressure, and the pressure of the dry air, they have a double progression, with four turning-points.

Annual Variation.—Table XXXIX. exhibits the monthly means. The temperature in the shade and in the sun's rays decreases from January to July, and then increases from July to January. The atmospheric pressure increases from February to August, and then decreases from August to February; and the march of the dry pressure is similar. The vapour-pressure has a progression in direct agreement with that of the temperature, showing, however, a tendency to a second maximum in August. With respect to the humidity, we see that it has a double progression, with two maxima in February and August, and two minima in June and November. The mean monthly force of the wind also has, upon the whole, a double progression, having two maxima in February and June, and two minima in April and November. The rainfall, too, has a double progression, with two maxima in February and August, and two minima in June and September. The amount of cloud has a maximum in February and a minimum in June, with a tendency to a second maximum in August. A similar remark applies to the frequency of lightning.

Table XL. gives the means of the extreme monthly range of the principal elements. The temperature and humidity are, on the whole, subject to greater fluctuations in the summer than in the winter months, and the greatest fluctuations of the vapour-pressure take place from January to June inclusive. A comparison of the oscillations of the total atmospheric pressure and vapour-pressure will show the important part played by the latter.

Secular Variation.—Table XLI. exhibits the extreme annual range, and Table XLII. the annual means of the several elements for each year.

As might be expected of an island exposed to the bracing S.E. trade-wind, having a mean annual temperature of 67° to 77° (the temperature in the interior is from 4° to 10° lower than at Port Louis), and a mean humidity of 71, clothed with vegetation, and subject to so small variations of temperature and humidity, Mauritius possesses one of the best tropical climates in the world. At one time it was a sanatorium for invalids from India in search of health; and if, of late, it has been the scene of dreadful mortality, this is not to be ascribed to an unbountiful Nature, but, there is reason to fear, to a neglect and violation of her laws.

I mentioned at the outset that the site of the Observatory was objectionable. In conclusion I beg to state, that a new Observatory is about to be erected in a more favourable locality. The old Observatory and grounds have been sold for £10,000, and the local government have voted a portion of that sum for the erection of a new Observatory, which is to be supplied with self-recording meteorological and magnetical instruments. Plans of the buildings have been prepared at the request of the Secretary of State for the Colonies; and although Mauritius has lately been sorely tried, it is expected that the buildings will soon be commenced. The Governor, Sir Henry Barkly, who has done so much for science in other colonies, is a warm promoter of the measure, and His Excellency's influential endeavours are seconded by the principal Government officials and the leading planters and merchants. Nor can I close this communication without making mention with becoming respect of the efforts and recommendations of General Sabine, who, for a number of years, has lost no opportunity of urging the importance of Mauritius as a meteorological and magnetical station, and is still pleased to take much interest in the subject.

Table I.—Showing the Mean Temperature of the Air for each Observation Hour, derived from Six-hourly Observations taken daily from 1860 to 1866, both inclusive.

Months.	3½ A.M.	9½ A.M.	3½ P.M.	9½ P.M.	Monthly means.	(+) above (−) below mean for year.
	°	°	°	°	°	°
January	80·01	82·23	83·67	80·97	81·72	+4·61
February	79·87	81·61	82·98	80·58	81·26	+4·15
March	79·11	81·00	82·51	79·93	80·64	+3·53
April	78·21	80·38	81·77	79·07	79·86	+2·75
May	74·84	77·05	78·30	75·63	76·45	−0·66
June	72·31	73·70	75·37	72·65	73·46	−3·65
July	70·71	72·14	73·64	71·30	71·95	−5·16
August	70·81	72·50	73·95	71·57	72·21	−4·90
September	71·33	73·64	75·16	72·37	73·12	−3·99
October	73·48	75·85	77·07	74·50	75·22	−1·89
November	76·56	79·47	80·74	77·71	78·62	+1·51
December	78·95	81·53	82·64	80·04	80·79	+3·68
Mean for each hour	75·50	77·59	78·99	76·36	77·11	
(+) above (−) below mean	−1·61	+0·48	+1·88	−0·75		

TABLE II.—Showing the Mean Temperature of the Air at each Hour of the Day, derived from Hourly Observations taken on the 21st of each Month, from 1863 to 1866, both inclusive.

Hours.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Means.	Deviation from mean.
	°	°	°	°	°	°	°	°	°	°	°	°	°	
6 A.M.	80.22	79.92	79.08	78.30	74.68	71.38	70.32	71.00	71.64	73.97	76.95	79.10	75.55	−1.59
7 "	80.56	80.40	79.16	78.54	74.66	71.40	70.34	71.12	71.76	74.37	77.35	80.07	75.77	−1.37
8 "	81.28	80.72	79.78	79.26	75.10	72.02	70.60	71.58	72.44	75.32	78.20	80.55	76.54	−0.60
9 "	82.00	81.36	80.62	80.20	75.52	73.10	71.38	72.40	72.88	76.27	79.27	81.30	77.11	−0.03
10 "	82.50	82.26	81.64	81.00	76.58	74.64	72.26	73.04	73.50	77.10	80.52	82.47	78.12	+0.98
11 "	82.62	82.76	82.44	80.48	77.38	75.38	73.26	73.84	74.16	77.35	81.02	82.32	78.92	+1.78
Noon	83.28	83.38	82.56	81.90	77.88	76.00	73.56	74.14	75.00	77.70	81.62	83.17	79.18	+2.04
1 P.M.	83.76	83.77	82.58	81.90	78.12	76.02	73.66	74.56	75.20	77.97	82.05	83.62	79.43	+2.29
2 "	83.76	83.52	82.38	81.78	78.68	75.76	73.88	74.42	74.88	77.75	82.07	83.47	79.36	+2.22
3 "	83.40	83.12	82.06	81.74	78.60	75.38	73.68	74.60	74.90	77.72	82.27	83.17	79.22	+2.08
4 "	83.00	83.06	82.00	81.80	77.78	74.92	73.18	74.00	74.38	77.50	82.10	82.67	78.86	+1.72
5 "	82.54	82.84	81.36	80.70	76.62	74.20	72.30	73.70	73.76	76.95	81.42	82.30	78.22	+1.08
6 "	82.36	82.40	80.92	79.96	75.88	73.48	71.96	72.94	72.98	76.05	80.40	81.97	77.61	+0.47
7 "	82.12	81.78	80.44	79.54	75.60	73.18	71.48	72.60	72.60	75.55	79.22	80.87	77.08	−0.06
8 "	81.78	81.60	79.96	79.26	75.48	72.86	71.24	72.24	72.34	75.22	78.60	80.50	76.76	−0.38
9 "	81.28	80.74	79.60	79.10	75.26	72.80	71.04	72.14	72.26	75.07	78.25	80.02	76.46	−0.68
10 "	81.00	80.56	79.66	78.98	75.26	72.74	70.96	71.86	72.12	74.90	78.05	79.65	76.31	−0.83
11 "	80.84	80.46	79.56	79.20	75.00	72.64	70.60	71.72	71.96	74.77	77.57	79.65	76.19	−0.95
Midnight	80.68	80.50	79.38	78.88	74.62	72.56	70.58	71.50	71.82	74.45	77.07	79.45	75.96	−1.18
1 A.M.	80.50	80.38	79.26	78.88	74.52	72.70	70.44	71.56	71.58	74.47	77.07	79.35	75.89	−1.25
2 "	80.52	80.28	79.00	78.76	74.72	72.54	70.52	71.60	71.78	74.45	77.12	78.53	75.82	−1.32
3 "	80.54	80.18	78.94	78.74	74.40	72.30	70.58	71.44	71.72	74.35	77.12	78.32	75.72	−1.42
4 "	80.30	80.18	78.96	78.82	74.45	72.48	70.62	71.50	71.54	74.20	77.07	78.45	75.71	−1.43
5 "	80.40	79.98	79.10	78.66	74.45	72.22	70.58	71.30	71.28	73.97	76.95	78.30	75.59	−1.55
Mean.	81.72	81.49	80.43	79.88	75.88	73.45	71.70	72.53	72.85	75.72	79.14	80.80	77.14	
(+) above (−) below mean...	+4.58	+4.35	+3.29	+2.74	−1.26	−3.69	−5.44	−4.61	−4.29	−1.42	+2.00	+3.66		

TABLE III.—Showing the Greatest Range of Temperature on any one Day in each Month, from 1862 to 1866, both inclusive.

Months.	1862.	1863.	1864.	1865.	1866.	Monthly means.
	°	°	°	°	°	°
January	9·3	10·4	9·1	12·4	11·0	10·4
February	8·1	7·2	11·1	11·0	12·0	9·9
March	7·0	8·3	11·2	9·0	13·0	9·7
April	9·5	9·8	9·2	10·0	11·0	9·9
May	11·1	8·8	12·7	10·9	9·5	10·6
June	11·3	7·8	9·4	7·0	8·4	8·8
July	8·7	11·3	10·0	7·1	7·3	8·9
August	7·3	9·4	9·6	7·6	11·3	9·0
September	6·9	10·0	9·8	10·5	11·0	9·6
October	6·4	8·4	9·5	10·0	9·5	8·7
November	6·4	10·6	12·1	10·0	10·9	10·0
December	8·9	12·5	12·0	9·3	11·2	10·8
Yearly means	8·41	9·54	10·47	9·56	10·50	9·69

TABLE IV.—Showing the Least Range of Temperature on any one Day in each Month, from 1862 to 1866, both inclusive.

Months.	1862.	1863.	1864.	1865.	1866.	Monthly means.
	°	°	°	°	°	°
January	4·6	3·0	5·1	6·0	4·6	4·6
February	5·0	3·3	3·4	4·0	5·1	4·1
March	4·8	3·4	4·4	3·9	4·5	4·2
April	5·7	3·2	3·0	4·0	3·1	3·8
May	3·9	4·6	3·0	3·6	1·5	3·3
June	3·8	3·9	4·5	4·0	1·4	3·5
July	2·1	3·1	3·0	3·5	3·1	2·9
August	2·1	4·2	4·5	3·0	3·4	3·4
September	0·7	3·5	5·0	3·8	4·1	3·4
October	2·1	5·5	5·1	3·9	2·2	3·6
November	3·9	5·8	5·0	3·9	6·0	4·9
December	4·0	3·3	5·0	3·0	5·4	4·1
Yearly means	3·56	3·65	4·25	3·90	3·70	3·81

TABLE V.—Showing the Mean Diurnal Range of Temperature for each Month and Year, from 1862 to 1866, both inclusive.

Months.	1862.	1863.	1864.	1865.	1866.	Monthly means.
	°	°	°	°	°	°
January	6·5	6·0	7·5	8·1	7·2	7·1
February	6·9	5·3	7·1	7·4	8·5	7·0
March	6·2	5·7	7·3	6·3	8·0	6·7
April	7·4	6·8	6·5	6·9	6·9	6·9
May	7·2	6·6	8·0	7·0	5·6	6·9
June	6·9	5·7	6·8	5·5	5·3	6·0
July	5·0	6·3	6·4	5·8	5·3	5·8
August	4·3	6·6	6·4	5·9	5·8	5·8
September	4·7	6·9	7·1	7·2	6·5	6·5
October	4·8	7·2	7·2	6·7	5·9	6·4
November	4·9	8·2	8·7	7·9	8·9	7·7
December	6·5	7·7	7·8	6·6	8·7	7·5
Yearly means	5·94	6·60	7·23	6·78	6·90	6·69

TABLE VI.—Showing the Mean Temperature of the Air for each Month and Year, from 1860 to 1866, both inclusive.

Months.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Monthly means.	Deviation from mean for year.
	°	°	°	°	°	°	°	°	°
January	81·22	82·85	81·42	82·32	81·37	82·22	80·62	81·72	+4·61
February	80·90	80·10	81·12	81·55	81·02	82·17	81·97	81·26	+4·15
March	80·02	79·75	79·92	81·48	80·47	80·87	81·95	80·64	+3·53
April	78·77	79·27	79·92	80·55	79·17	80·50	80·82	79·86	+2·75
May	76·62	76·70	75·97	77·82	75·07	76·70	76·30	76·45	−0·66
June	73·00	73·05	74·35	74·00	73·15	72·85	73·82	73·46	−3·65
July	72·77	71·87	72·95	71·11	71·42	71·75	71·80	71·95	−5·16
August	73·15	71·30	73·85	72·05	71·35	71·87	71·85	72·20	−4·91
September	74·07	72·70	74·72	73·05	72·52	72·82	71·95	73·12	−3·99
October	75·25	75·65	76·35	74·42	76·07	75·25	73·60	75·22	−1·89
November	79·27	78·30	79·15	76·75	78·57	78·85	79·45	78·62	+1·51
December	81·02	81·25	82·32	79·62	80·47	79·32	81·52	80 79	+3·68
Yearly means.	77·17	76·90	77·67	77·10	76·72	77·10	77·14	77·11	

Table VII.—Showing the Mean Temperature of the Air for each Month and Year, obtained from Daily Observations of the Maximum and Minimum Thermometers, from 1860 to 1866, both inclusive.

Months.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Monthly means.	Deviation from mean.
	°	°	°	°	°	°	°	°	°
January ...	81·20	82·30	82·55	83·20	82·45	82·85	81·60	82·30	+4·50
February ...	82·10	80·10	82·45	82·35	81·95	83·20	82·75	82·16	+4·31
March	80·90	79·90	81·20	82·25	81·65	81·85	83·00	81·53	+3·73
April	79·90	79·35	80·80	81·20	80·15	81·45	81·55	80·63	+3·83
May	77·70	76·65	77·20	78·70	75·70	77·50	76·40	77·12	−0·68
June	74·45	73·10	74·15	74·85	73·90	73·65	73·95	74·00	−3·80
July	73·40	72·40	73·20	71·18	72·10	72·60	72·05	72·52	−5·28
August	74·35	71·70	73·75	73·00	72·20	72·75	72·10	72·83	−4·97
September	75·55	73·10	74·75	74·05	73·35	73·60	72·05	74·16	−3·64
October	76·30	75·50	76·50	75·40	76·90	76·25	73·65	75·78	−2·02
November ..	80·00	78·65	79·35	77·60	79·35	79·65	79·95	79·22	+1·42
December...	81·05	81·25	82·95	80·45	81·60	80·30	82·45	81·44	+3·64
Yearly means	77·80	77·00	78·23	77·93	77·61	77·97	77·62	77·80	

Table VIII.—Showing the Mean Monthly Maximum Temperature in the Sun's Rays, obtained from Daily Observations of the Black Bulb Thermometer (*in vacuo*), from 1860 to 1866, both inclusive.

Months.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Monthly means.
	°	°	°	°	°	°	°	°
January	119·1	118·5	117·5	116·5	116·8	117·9	117·0	117·6
February	116·9	112·4	116·4	113·2	115·3	115·0	118·1	115·3
March	119·1	115·0	114·6	114·3	114·5	115·2	117·4	115·7
April	115·6	114·3	114·3	112·9	110·9	112·1	111·6	113·1
May	108·3	104·5	105·9	108·2	103·6	106·2	106·2	106·1
June	105·0	102·9	103·4	102·5	101·4	102·3	102·2	102·8
July	103·0	101·8	102·7	100·0	99·8	100·9	100·6	101·2
August	108·1	103·3	103·1	104·2	103·3	102·9	102·9	104·0
September	111·3	106·9	109·3	106·6	106·2	105·9	104·9	107·3
October	113·8	112·8	112·4	111·2	112·2	111·5	112·0	112·3
November	118·2	115·5	114·3	113·5	114·6	116·0	112·8	115·0
December	117·1	117·3	116·5	115·5	116·0	113·2	115·3	115·8
Yearly means.........	112·9	110·4	110·9	109·9	109·5	109·9	110·1	110·5

TABLE IX.—Showing the Maximum and Minimum Temperature, and the Extreme Range of Temperature in each Month, from 1860 to 1866, both inclusive.

Months.		1860.	1861.	1862.	1863.	1864.	1865.	1866.	Monthly means.
January	Maximum	88·1°	88·0°	88·0°	88 0°	87·5°	89·0°	88·0°	88·07°
	Minimum	73·0	76·5	76·9	75·0	77·8	75·6	74·0	75·54
	Range ...	15·3	11·5	11·1	13·0	9·7	13·4	14·0	12·55
February	Maximum	87·0	87·5	87·0	86·9	88·0	90·0	88·2	87·80
	Minimum	75·0	72·0	76·9	77·1	75·6	75·5	76·0	75·44
	Range ...	12·0	15·5	10·1	9 8	12·4	14·5	12·2	12·36
March ...	Maximum	85·0	85·8	87·5	87·5	87·1	88·0	88·6	87·07
	Minimum	73·0	75 0	75·0	77·2	74·1	76 5	75·0	75·24
	Range ...	12 0	10·8	11·6	10·3	13·0	11 5	13·6	11·83
April.....	Maximum	86·0	85·5	87 0	86·9	86·9	88·0	89·0	87·04
	Minimum	71·5	74·0	74·9	75·4	73·9	76·0	74·0	74·24
	Range ...	14·5	11·5	12·1	11·5	13·0	12·0	15·0	12·80
May	Maximum	82·0	82·2	86·1	85·4	82·1	85·0	84·0	83·83
	Minimum	70·0	72·0	70·8	71·4	66·8	71 9	69·2	70·30
	Range ...	12·0	10·2	15·3	14·0	15·3	13·1	14·8	13·53
June	Maximum	79·0	79·8	80·2	81·4	81·2	79·5	79·0	80·01
	Minimum	66·5	67·2	68 0	70·0	66·4	67·8	65·5	67·34
	Range .	12·5	12·6	12·2	11·4	14·8	11·7	13·5	12·67
July	Maximum	79·0	76·0	79·5	78·2	78·4	77·0	78·4	78·07
	Minimum	68·5	68·2	68 2	65 9	66·5	67·6	66·1	67·29
	Range ..	10·5	7·8	11·3	12·3	11·9	9·4	12·3	10·78
August ...	Maximum	79·0	76·0	78·3	79·5	79·0	78·0	78·0	78·25
	Minimum	68·0	67·8	69·0	66·6	66·0	68·0	62·8	66·89
	Range ...	11·0	8 2	9·8	12·9	13·0	10·0	15·2	11·36
September	Maximum	80·5	78·9	79·0	79 5	80·0	80·0	78·5	79·49
	Minimum	69 0	67·0	70 0	68·0	67·2	68·0	64·6	67·69
	Range ...	11·5	11·9	9·0	11·5	12·8	12·0	13·9	11·80
October...	Maximum	82·0	81·0	80·4	81·0	83·4	81·5	80·0	81·29
	Minimum	67·5	70·5	74·0	69·9	71·0	69·0	68·4	69·93
	Range ..	14·5	10·5	6·4	11·1	12·4	12·5	11·6	11·36
November	Maximum	86·0	83·5	85·0	85·2	88·0	86·0	86·9	85·80
	Minimum	73·5	73·0	73·6	71·9	70·0	73·6	73·4	72·71
	Range ...	12·5	10·5	11·4	13 3	18·0	12·4	13·5	13·09
December	Maximum	87·0	86·5	89·4	87·3	89·0	87·0	89·6	87·97
	Minimum	74·5	76·0	75·4	71·9	74·0	74·0	75·2	74·43
	Range ...	12·5	10·5	14·0	15·4	15·0	13·0	14·4	13·54
Yearly means.	Maximum	83·38	82·56	83·96	83·90	84·22	84·09	84·01	83·74
	Minimum	70·82	71·67	72·73	71·69	70·78	71·96	70·35	71·43
	Range ..	12·56	10·89	11·23	12·21	13·44	12·13	13·66	12·30

TABLE X.—Showing the Highest and Lowest Readings of the Self-registering Thermometers, the Dates of occurrence, and the Range in each Year.

Years	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Means.
Maximum ...	88°·1	88°0	89°·4	88°·0	89°·0	90°·0	89°·0	88°·77
Date	31st Jan.	14th Jan.	27th Dec.	23rd Jan.	2nd Dec.	4th Feb.	1st April.	23rd Jan.
Minimum ...	66·5	67 0	68·0	65·9	66·0	67·6	62·8	66·25
Date	22nd June.	11th Sept.	24th June.	8th July.	2nd Aug.	10th July.	29th Aug.	24th July.
Range.......	21·6	21·0	21·4	22·1	23·0	22·4	26·2	22·52

TABLE XI.—Showing the Mean Vapour-pressure for each Observation Hour, obtained from Six-hourly Observations taken daily during seven years (1860–66).

Months.	3½ A.M.	9½ A.M.	3½ P.M.	9½ P.M.	Monthly means.	Deviation from mean.
January	·749	·764	·767	·758	·759	+·107
February	·756	·772	·773	·766	·767	+·115
March	·736	·749	·752	·738	·744	+·092
April	·706	·715	·719	·713	·713	+·061
May	·630	·639	·639	·635	·636	−·016
June	·564	·575	·580	·570	·572	−·080
July	·547	·555	·551	·546	·550	−·102
August	·555	·562	·565	·564	·561	−·091
September	·553	·557	·562	·560	·558	−·094
October	·591	·595	·599	·597	·595	−·057
November	·649	·654	·659	·655	·654	−·002
December	·714	·716	·725	·723	·719	+·067
Means	·646	·654	·658	·652	·652	
Deviation from mean..	−·006	+·002	+·006	·000		

TABLE XII.—Showing the Mean Vapour-pressure for each Hour of the Day, from the Term-day Observations (1863–66).

Hours.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.	Deviation from mean.
6 A.M.	·737	·807	·719	·664	·585	·533	·522	·548	·529	·549	·630	·713	·628	—·007
7 „	·737	·819	·738	·676	·581	·537	·519	·554	·526	·546	·636	·731	·633	—·002
8 „	·764	·830	·739	·669	·605	·554	·529	·550	·535	·549	·652	·729	·642	+·007
9 „	·764	·836	·724	·643	·601	·553	·532	·546	·534	·550	·676	·718	·640	+·005
10 „	·761	·832	·728	·648	·605	·563	·517	·560	·527	·578	·676	·733	·644	+·009
11 „	·763	·823	·740	·658	·611	·547	·524	·574	·533	·584	·658	·720	·645	+·010
Noon	·776	·832	·756	·656	·609	·541	·522	·563	·520	·576	·640	·740	·644	+·009
1 P.M.	·769	·823	·763	·651	·605	·557	·519	·557	·533	·590	·647	·739	·646	+·011
2 „	·781	·821	·745	·656	·612	·561	·517	·559	·542	·589	·636	·737	·646	+·011
3 „	·765	·820	·756	·652	·606	·553	·513	·554	532	·594	·637	·725	·644	+·009
4 „	·762	·808	·721	·653	·598	·545	·512	·566	·525	·552	·635	·710	·634	—·001
5 „	·759	·816	·731	·659	·604	·557	·504	·552	·529	·556	·638	·730	·636	+·001
6 „	·741	·814	·725	·674	·605	·558	·499	·554	·523	552	·642	·727	·634	—·001
7 „	·733	·810	·734	·681	·603	·553	·509	·561	525	·562	·640	·688	·633	—·002
8 „	·727	·815	·732	·675	·596	·553	·515	·564	·527	·561	·643	·696	·634	—·001
9 „	·725	·818	·734	·684	·600	·561	·505	·556	·533	·563	·642	·688	·634	—·001
10 „	·719	·813	·720	·683	·591	·568	·502	·552	·536	·573	·645	·688	·632	—·003
11 „	·725	·812	·720	·678	·583	·542	·497	·540	·532	·584	·656	·699	·631	—·004
Midnight	·713	·814	·720	·672	·574	·546	·511	·531	·529	·582	·659	·689	·629	—·006
1 A.M.	·728	·807	·732	·666	·574	·550	·518	·542	·523	·584	·650	·687	·630	—·005
2 „	·727	·804	·722	·665	·575	·564	·521	·549	·524	·583	·640	·680	·629	—·006
3 „	·723	·804	·710	·669	·571	·555	·520	·542	·517	·572	·637	·677	·625	—·010
4 „	·734	·797	·710	·659	·563	·544	·522	·529	·507	·575	·632	·676	·621	—·014
5 „	·736	·795	·721	·659	·566	·545	·504	·534	·524	·582	·629	·684	·623	—·012
Means..........	·745	·815	·731	·665	·593	·552	·515	·551	·528	·570	·645	·709	·635	
Deviation from mean.	+·110	+·180	+·096	+·030	—·042	—·083	—·120	—·084	—·107	—·065	+·010	+·074		

TABLE XIII.—Showing the Mean Vapour-pressure for each Month and Year, derived from Six-hourly Observations taken daily from 1860 to 1866, both inclusive.

Months.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Monthly means.	Deviation from mean.
January......	·773	·770	·774	·773	·725	·754	·749	·759	+·107
February ...	·792	·757	·764	·773	·739	·790	·752	·767	+·115
March	·769	·725	·720	·767	·738	·738	·743	·743	+·091
April	·698	·708	·731	·711	·709	·710	·725	·713	+·061
May	·662	·663	·640	·644	·600	·629	·621	·637	−·015
June	·585	·559	·563	·586	·567	·570	·573	·572	−·080
July	·605	·540	·585	·531	·547	·544	·498	·550	−·102
August	·628	·557	·587	·554	·550	·549	·508	·562	−·090
September...	·625	·536	·584	·558	·535	·558	·507	·558	−·094
October	·627	·613	·595	·579	·619	·607	·531	·596	−·056
November ...	·649	·687	·689	·627	·681	·674	·575	·655	+·003
December . .	·747	·748	·722	·717	·710	·741	·650	·719	+·067
Yearly means	·680	·655	·663	·652	·643	·655	·619	·652	
Deviation from mean	+·028	+·003	+·011	0·000	−·009	+·003	−·033		

The above Table, as already remarked, indicates a gradual decrease of the vapour-pressure. This becomes more evident when we take the means for consecutive periods of two years each. Thus:—

Years.	Vap.-pressure.	Means.
1860	·680	·667
1861	·655	
1862	·663	·657
1863	·652	
1864	·643	·649.
1865	·655	

The pressure for 1866 (·619) is so much lower than the greatest (·680) that it is very probable the mean pressure for 1866 and 1867 will be the least of all.

It is possible that this diminution of vapour-pressure may be owing to the great extent to which the primeval forests have been cut down during the last twenty years. As the rains are evaporated and carried away sooner than they would be if protected from the sun's rays, we may suppose that the mean annual amount of vapour in the air must be less than it was before the forests were cut down; and that if this is the case at Port Louis, on the west coast, it must be still more so in the interior of the island, where the forests existed.

TABLE XIV.—Showing the Maximum and Minimum Vapour-pressure, and its Extreme Range, for each Month, from 1860 to 1866, both inclusive.

Months.		1860.	1861.	1862.	1863.	1864.	1865.	1866.	Monthly means.
January	Maximum	·914	·896	·903	·955	·827	·910	·925	·904
	Minimum	·657	·659	·638	·659	·638	·617	·607	·639
	Range ...	·257	·237	·265	·296	·189	·293	·318	·265
February	Maximum	·879	·847	·896	·925	·854	·940	·940	·897
	Minimum	·707	·620	·643	·715	·597	·628	·617	·647
	Range ...	·172	·227	·253	·210	·257	·312	·323	·250
March ...	Maximum	·866	·814	·903	·868	·868	·940	·840	·871
	Minimum	·594	·626	·519	·648	·578	·597	·648	·601
	Range ...	·272	·188	·384	·220	·290	·343	·192	·270
April......	Maximum	·872	·847	·847	·854	·840	·827	·854	·849
	Minimum	·542	·586	·622	·578	·607	·559	·578	·581
	Range ...	·330	·261	·225	·276	·241	·268	·276	·268
May	Maximum	·805	·756	·745	·727	·787	·840	·840	·786
	Minimum	·503	·571	·460	·578	·450	·481	·515	·508
	Range ...	·302	·185	·285	·149	·337	·359	·325	·277
June......	Maximum	·694	·789	·704	·739	·692	·751	·670	·720
	Minimum	·443	·463	·450	·473	·450	·437	·450	·452
	Range ...	·251	·326	·254	·266	·242	·314	·220	·268
July	Maximum	·722	·636	·681	·638	·692	·638	·646	·665
	Minimum	·507	·449	·489	·400	·408	·465	·383	·443
	Range ...	·215	·187	·192	·238	·284	·173	·263	·222
August ...	Maximum	·721	·686	·692	·659	·692	·704	·621	·682
	Minimum	·505	·474	·464	·461	·408	·435	·382	·447
	Range ...	·216	·212	·228	·198	·284	·269	·239	·235
September	Maximum	·760	·628	·670	·692	·607	·692	·637	·669
	Minimum	·514	·470	·473	·450	·458	·465	·367	·456
	Range ...	·246	·158	·197	·242	·149	·227	·270	·213
October...	Maximum	·752	·776	·715	·727	·727	·727	·648	·724
	Minimum	·482	·520	·506	·481	·541	·498	·410	·491
	Range ...	·270	·256	·209	·246	·186	·239	·238	·233
November	Maximum	·783	·827	·827	·751	·827	·854	·598	·781
	Minimum	·542	·513	·541	·541	·550	·578	·533	·542
	Range ...	·241	·314	·286	·210	·277	·276	·065	·239
December	Maximum	·859	·868	·840	·827	·814	·868	·802	·840
	Minimum	·668	·622	·617	·597	·588	·617	·513	·603
	Range ..	·191	·246	·223	·230	·226	·251	·289	·237
Yearly means.	Maximum	·802	·781	·785	·780	·769	·807	·752	·782
	Minimum	·555	·548	·535	·548	·522	·531	·500	·534
	Range ...	·247	·233	·250	·232	·247	·276	·252	·248

TABLE XV.—Showing the Greatest and Least Vapour-pressure, the Dates of occurrence, and the Range in each Year.

Years	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Means.
Maximum ...	·914	·896	·903	·955	·868	·940	·940	·916
Date	29th Jan.	31st Jan.	27th Jan.	19th Jan.	6th March.	19th Feb.	21st Feb.	8th Feb.
Minimum ...	·446	·449	·450	·400	·408	·435	·367	·421
Date	20th June.	19th June.	15th June.	20th July.	31st July.	12th Aug.	27th Sept.	21st July.
Range.........	·467	·447	·453	·555	·460	·505	·573	·494

TABLE XVI.—Showing the Mean Humidity of the Air (complete saturation being 100) for each Observation Hour, obtained from Six-hourly Observations taken daily during seven years (1860–1866).

Months.	$3\frac{1}{2}$ A.M.	$9\frac{1}{2}$ A.M.	$3\frac{1}{2}$ P.M.	$9\frac{1}{2}$ P.M.	Monthly means.	Deviation from mean.
January............	74·7	71·2	68·5	73·5	72·0	+1·1
February	77·1	74·3	71·4	76·0	74·7	+3·8
March	75·3	72·3	69·4	73·9	72·7	+1·8
April...............	74·5	70·4	68·1	73·3	71·6	+0·7
May	73 6	70·3	67·3	72 9	71·0	+0·1
June	72·3	70·1	67·4	71·7	70·4	−0·5
July	72·9	71·1	66·5	71·9	70·6	−0·3
August	73 8	70·9	68·2	73·4	71·6	+0·7
September..	72·6	67·7	65·2	71·3	69·2	−1·7
October............	72 6	67·6	65·0	70·8	69·0	−1·9
November	71·9	66·0	64·1	70·4	68·1	−2·8
December	73·6	68·5	66·3	71·9	70·1	−0·8
Monthly means...	73·7	70·0	67·3	72·6	70·9	
Deviation from mean.........	+2·8	−0·9	−3·6	+1·7		

TABLE XVII.—Showing the Mean Humidity of the Air (complete saturation being 100) for each hour of the Day, derived from the Term-day Observations (1863–66).

Hours.	January.	February.	March.	April.	May.	June.	July.	August.	Septem.	October.	Novem.	December.	Means.	Deviation from mean.
6 A.M. ...	70·2	78·4	69·5	69·2	67·5	68·0	69·9	72·0	68·6	65·4	67·9	71·3	69·8	+2·4
7 ,, ...	70·2	78·5	71·6	70·2	66·3	68·1	69·8	72·7	68·0	63·9	67·3	71·0	69·8	+2·4
8 ,, ...	70·8	78·9	70·4	67·8	67·7	69·1	70·4	72·3	67·1	62·4	67·5	69·6	69·5	+2·1
9 ,, ...	69·5	77·7	66·9	64·0	66·9	67·2	68·8	69·4	66·5	60·7	67·5	66·8	67·6	+0·2
10 ,, ...	67·7	75·3	64·9	61·4	65·2	65·2	65·2	70·1	64·8	62·2	63·3	66·4	66·0	−1·4
11 ,, ...	67·7	73·4	63·9	61·6	64·4	63·7	63·7	70·3	64·1	62·0	61·9	65·6	65·0	−2·4
Noon	67·3	72·8	65·6	60·8	62·9	63·6	63·6	68·2	60·5	61·4	58·5	65·1	63·9	−3·5
1 P.M. ...	65·6	71·5	66·0	60·4	62·2	62·1	62·1	66·2	62·0	62·0	58·3	63·9	63·6	−3·8
2 ,, ...	66·6	71·8	65·7	61·2	61·8	61·4	61·4	67·6	63·3	61·9	57·2	65·8	64·0	−3·4
3 ,, ...	65·7	72·3	67·2	60·9	61·3	60·7	60·7	66·2	62·1	62·5	57·1	65·6	63·9	−3·5
4 ,, ...	67·1	72·3	65·4	62·0	61·5	62·7	62·7	68·5	61·2	58·4	57·1	65·6	63·8	−3·6
5 ,, ...	68·1	72·6	66·4	63·4	65·0	63·5	63·5	67·3	63·7	60·0	58·8	65·8	65·1	−2·3
6 ,, ...	66·7	73·9	67·0	66·5	66·7	63·2	63·2	68·6	65·2	61·6	61·3	67·7	66·3	−1·1
7 ,, ...	67·7	74·9	69·2	68·0	66·9	65·4	65·4	70·9	66·3	63·3	63·5	65·0	67·4	0·0
8 ,, ...	66·9	75·8	69·9	68·2	66·7	66·8	66·8	71·6	67·6	64·2	65·1	66·0	68·1	+0·7
9 ,, ...	67·6	76·8	70·8	69·3	66·9	66·0	66·0	70·8	68·3	64·8	66·0	66·6	68·6	+1·2
10 ,, ...	68·0	77·4	69·5	69·8	66·0	66·6	66·6	70·1	68·8	65·9	66·6	68·0	68·9	+1·5
11 ,, ...	67·7	77·8	69·6	69·0	67·2	66·2	66·2	69·9	68·7	68·0	68·5	69·0	69·1	+1·7
Midnight..	68·0	78·1	69·8	68·7	66·8	68·2	68·2	69·0	68·8	67·8	70·4	68·6	69·3	+1·9
1 A.M. ...	69·5	77·4	71·2	68·4	67·1	69·3	69·3	70·9	68·7	68·2	69·5	68·5	69·7	+2·3
2 ,, ...	69·7	77·2	71·3	68·3	67·0	69·7	69·7	71·3	68·5	68·2	67·8	69·8	69·9	+2·5
3 ,, ...	68·1	77·4	70·4	68·9	67·2	70·1	70·1	71·0	67·8	67·3	67·7	69·9	69·6	+2·2
4 ,, ...	71·5	76·5	70·4	67·2	65·7	70·4	70·4	69·2	66·2	67·8	66·8	69·6	69·0	+1·6
5 ,, ...	70·3	76·7	71·5	67·9	66·2	67·6	67·6	70·5	69·0	69·6	66·8	70·8	69·6	+2·2
Means......	68·3	75·6	68·5	65·9	65·7	66·9	66·3	69·8	66·1	64·1	64·3	67·6	67·4	

TABLE XVIII.—Showing the Mean Humidity of the Air for each Month and Year, from 1860 to 1866, both inclusive.

Months.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Monthly means.	Deviation from mean.
January	74·6	70·4	74·5	71·6	69·3	70·2	73·1	71·9	+1·0
February	77·0	76·2	74·0	79·5	71·6	73·8	70·6	74·7	+3·8
March	76·5	73·1	72·7	73·2	72·8	71·7	69·9	72·8	+1·9
April	72·6	72·4	73·0	69·9	72·8	69·6	70·7	71·6	+0·7
May	73·3	73·5	72·7	68·6	70·0	69·2	69·8	71·0	+0·1
June	71·2	69·6	69·1	71·0	70·4	71·3	69·8	70·3	−0·6
July	75·6	69·9	73·5	69·1	71·9	70·8	63·4	70·6	−0·3
August	77 8	73·4	71·1	70·4	72·4	71·3	64·7	71·6	+0·7
September	75·7	67·7	69·5	69·6	68·0	70·1	64·2	69·2	−1·7
October	72·3	70·3	66·7	68·7	70·2	70·5	63·8	68·9	−2·0
November	67·3	72·3	70·6	69·0	70·2	70·1	57·0	68·1	−2·8
December	72·2	71·8	67·6	72·4	70 0	75·9	60·2	70·0	−0·9
Yearly means.	73·6	71·7	71·2	71·1	70·8	71·2	66·4	70·9	
Deviation from mean.	+2·7	+0·8	+0·3	+0·2	−0·1	+0·3	−4·5		

We have seen that Table XIII. indicates a decrease of vapour-pressure. We now see that Table XVIII. indicates a decrease of humidity; in other words, an increasing dryness of the air. This decrease is perhaps more apparent when we take the means for periods of two years each. Thus:—

Years.	Humidity.	Means.
1860	73·6	72·6
1861	71·7	
1862	71·2	71·1
1863	71·1	
1864	70·8	71·0.
1865	71·2	

The humidity for 1866 is so small as to render it almost certain that the mean for 1866 and 1867 will be the least of all.

These results are interesting in connexion with the destruction of the forests, and the diminishing sugar-crops.

The year 1866 was remarkable not only for diminished humidity, but also for diminished vapour-pressure, diminished rainfall, absence of hurricanes, and a severe drought, which, after destroying a large portion of the young canes, was followed by a terrible fever, which has not yet disappeared. At the Observatory the

Humidity was .... 66·4 (100—0).
Vapour-pressure .... 0·619 inch.
Rainfall .... 20·56 inches.

Table XIX.—Showing the Maximum and Minimum Humidity, and the Extreme Range of Humidity, for each Month, from 1860 to 1866, both inclusive.

Months.		1860.	1861.	1862.	1863.	1864.	1865.	1866.	Monthly means.
January	Maximum	94·1	86·6	88·8	86·8	82·6	86·6	91·0	88·1
	Minimum	55·4	61·8	56·2	58·9	56·1	58·9	53·4	57·2
	Range ...	38·7	24·8	32 6	27·9	26·5	27·7	37·6	30·9
February	Maximum	91·8	95·3	90·9	86·7	86·5	90·9	86·7	89·8
	Minimum	61·0	57·6	58 8	64·7	56·1	53·6	53·6	57·9
	Range ...	30·8	37·7	32·1	22·0	30·4	37·3	33·1	31·9
March ...	Maximum	87·5	93·6	88·8	82·6	86·7	86·6	82·5	86·9
	Minimum	56·7	58·9	60·3	61·7	55·8	55·9	56·2	57·9
	Range ...	30·8	34 7	28·5	20·9	30·9	30·7	26·3	29·0
April......	Maximum	87·8	88·8	78·7	90·7	86·7	82·6	82·4	85·4
	Minimum	57·4	57·4	60·2	55·8	58·8	61·8	58·7	58·6
	Range ...	30·4	31·4	18·5	34·9	27·9	20·8	23·7	26·8
May	Maximum	85·4	84·9	82·4	82·3	86·7	86·5	86·7	85·0
	Minimum	58·1	57·1	59·5	58·6	52·6	55·3	58·2	57·1
	Range ...	27·3	27·8	22·9	23·7	34·1	31·2	28·5	27·9
June	Maximum	87·8	86·2	82·4	82·3	86·5	86·4	82·4	84·9
	Minimum	52·1	53·9	58·0	58·2	55·3	61·0	58·0	56·7
	Range ...	35·7	32·3	24·4	24·1	31·2	25·4	24·4	28·2
July	Maximum	93·9	82·2	82·4	82·4	86·5	85·4	78·0	84·4
	Minimum	61·5	58·2	64·1	58·0	52·5	52·7	48·0	56·4
	Range ...	32·4	24·0	18·3	24·4	34·0	32·7	30·0	28·0
August ...	Maximum	96·7	86 5	86·5	78·4	90·7	90·7	79·0	86·9
	Minimum	65·3	59·6	55·6	55·3	55·1	52·5	52·6	56·5
	Range ..	31·4	26·9	30·9	23·1	35·6	38·2	26·4	30·4
September	Maximum	96·3	80·0	78·4	86·4	81·0	78·4	79·0	82·8
	Minimum	60·7	56·4	55·3	58·2	55·2	58 1	48·3	56·0
	Range ...	35·6	23·6	23·1	28·2	25·8	20·3	30·7	26·8
October...	Maximum	86·6	86·9	82·3	86·4	84·3	82·4	77·0	83·7
	Minimum	51·0	54·4	55·6	58·3	58·2	58·2	54·6	55·8
	Range ..	35·6	32·5	26·7	28·1	26 1	24·2	22·4	27·9
November	Maximum	81·7	86·5	82·3	82·3	82·6	82·4	69·6	81·0
	Minimum	56·6	49 6	53·3	52·8	55·8	55·8	52·1	53·7
	Range ...	25·1	36 9	29·0	29·5	26·8	26·6	17·5	27·3
December	Maximum	89·7	85·3	82·5	82·6	78·7	90·7	81·5	84·4
	Minimum	58·1	52·2	53·6	58·9	56·0	56·0	54·5	55·6
	Range ...	31·6	33·1	28·9	23·7	22·7	34·7	27·0	28·8
Means for years...	Maximum	89·9	86·9	83·9	84·1	84·9	85·8	81·3	85·3
	Minimum	57·8	56·4	57·6	58·2	55·6	56·6	54·0	56·6
	Range ...	32·1	30·5	26·3	25·9	29·3	29·2	27·3	28·7

TABLE XX.—Showing the Greatest and Least Humidity, the Dates of occurrence, and Range in each Year.

Years	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Means.
Maximum ...	96·7	95·3	90·9	90·7	90·7	90·9	91·0	92·31
Date	21st Aug.	16th Feb.	9th Feb.	5th April.	12th Aug.	12th Feb.	4th Jan.	8th April.
Minimum ..	50·3	46·3	53 3	52·8	52·5	52·5	48·0	50·81
Date	7th Oct.	10th June.	17th Nov.	1st Nov	11th July.	12th Aug.	26th July	29th Aug.
Range.........	46·4	49·0	37·6	37·9	38 2	38·4	43·0	41·5

TABLE XXI.—Showing the Mean Height of the Barometer (corrected and reduced to 32°) for each Observation Hour, obtained from Six-hourly Observations, taken daily, from 1860 to 1866, both inclusive.

Months.	3½ A.M.	9½ A.M.	3½ P.M.	9½ P.M.	Monthly means.
	in.	in.	in.	in.	in.
January	29·908	29·951	29·890	29·958	29·927
February	29·823	29·870	29·804	29·877	29·843
March	29·912	29·963	29·895	29·968	29·934
April	29·977	30·026	29·954	30·027	29·996
May	30·050	30·105	30·030	30·097	30·070
June	30 138	30·190	30·121	30·181	30·157
July	30·174	30·228	30·152	30·212	30·191
August	30·176	30·228	30·150	30·218	30·193
September	30·169	30·221	30·140	30·218	30·186
October	30·113	30·160	30·082	30·158	30 129
November	30·045	30·084	30·017	30·094	30·060
December	29·967	30·007	29·947	30·017	29·984
Means	30·038	30·086	30·015	30·085	30·056
Deviation from mean..	−·018	+·030	−·041	+·029	

TABLE XXII.—Showing the Mean Height of the Barometer (corrected and reduced to 32°) for each Hour of the Day, as obtained from the Term-day Observations (1863–1866).

Hours.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	No .	Dec.	Means.	Deviation from mean.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	
6 A.M.	29·954	29·773	29·975	29 996	30·098	30·140	30·199	30·211	30·228	30·103	30·044	29·994	30·060	+·003
7 „	·965	·792	·987	30·010	·105	·151	·211	·220	·239	·113	·052	30·007	·071	+·014
8 „	·974	·811	30·001	·020	·122	·169	·225	·231	·249	·120	·059	·008	·082	+·025
9 „	·975	·819	·011	·030	·132	·175	·242	·244	·255	·123	·059	·013	·090	+·033
10 „	·972	·819	·011	·028	·126	·173	·241	·243	·256	·117	·054	·005	·087	+·030
11 „	·966	·810	·002	·009	·109	·155	·230	·229	·238	·107	·045	29·998	·075	+·018
Noon	·985	·797	29·983	29·991	·085	·131	·203	·204	·215	·092	·031	·986	·059	+·002
1 P.M.	·947	·782	·968	·968	·066	·112	·178	·180	·192	·073	·022	·972	·039	—·018
2 „	·939	·765	·956	·959	·055	·103	·162	·166	·175	·061	·001	·958	·025	—·032
3 „	·932	·760	·946	·953	·056	·095	·154	·160	·164	·054	29·987	·947	·017	—·040
4 „	·936	·762	·947	·963	·064	·098	·155	·164	·170	·055	·984	·947	·020	—·037
5 „	·939	·768	·953	·974	·077	·114	·162	·173	·180	·067	·994	·959	·030	—·027
6 „	·950	·787	·962	·988	·087	·127	·169	·184	·199	·090	30·011	·973	·044	—·013
7 „	·972	·804	·981	30·001	·105	·138	·188	·199	·209	·113	·019	·995	·060	+·003
8 „	·978	·821	·999	·017	·126	·147	·197	·213	·228	·123	·027	30·015	·074	+·017
9 „	·987	·837	30·011	·025	·132	·160	·203	·221	·238	·134	·030	·028	·084	+·027
10 „	·995	·848	·012	·025	·131	·159	·204	·217	·238	·137	·035	·036	·086	+·029
11 „	·995	·841	·003	·023	·123	·154	·198	·213	·237	·127	·035	·025	·081	+·024
Midnight	·983	·835	29·987	·018	·114	·146	·192	·210	·230	·123	·017	·015	·072	+·015
1 A.M.	·970	·820	·966	·006	·105	·138	·186	·196	·211	·107	·004	·003	·059	+·002
2 „	·962	·803	·950	29·992	·097	·126	·174	·190	·200	·091	29·984	29·997	·047	—·010
3 „	·957	·792	·936	·983	·092	·115	·161	·181	·193	·084	·985	·986	·039	—·018
4 „	·958	·793	·934	·975	·091	·108	·160	·178	·187	·090	·986	·985	·037	—·020
5 „	29·968	29·799	29·939	29·982	30·092	30·108	30·162	30·182	30·197	30·102	29·994	29·993	30·043	—·014
Means............	29·964	29·802	29·976	29·997	30·099	30·135	30·191	30·200	30·214	30·100	30·019	29·994	30·057	
Deviation from mean.	—·093	—·255	—·081	—·060	+·042	+·078	+·134	+·143	+·157	+·043	—·038	—·063		

TABLE XXIII.—Showing the Mean Height of the Barometer (corrected and reduced to 32°) for each Month and Year, as derived from Six-hourly Observations taken daily from 1860 to 1866, both inclusive.

Months.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Monthly means.	Deviation from mean.
	in.	in.	in.	in.	in.	in.	in.	in.	in.
January ...	29·846	29·909	29·899	29·921	29·950	30·007	29·952	29·927	−·129
February ..	29·842	29·665	29·890	29·824	29·937	29·836	29·914	29·843	−·213
March......	29·859	29·950	29·944	29·929	29·923	29·960	29·969	29·934	−·122
April	30·026	30·035	30·018	29·957	29·986	29·990	29·965	29·996	−·060
May	30·048	30·050	30·062	30·102	30·080	30·080	30·062	30·070	+·014
June	30·171	30·127	30·093	30·170	30·195	30·190	30·159	30·157	+·101
July	30·196	30·182	30·151	30·161	30·219	30·237	30·195	30·191	+·135
August.....	30·167	30·187	30·174	30·184	30·206	30·221	30·212	30·193	+·137
September.	30·142	30·193	30·151	30·147	30·258	30·196	30·221	30·186	+·130
October ...	30·102	30·116	30·139	30·115	30·142	30·136	30·152	30·129	+·073
November.	30·088	30·026	29·992	30·057	30·064	30·085	30·102	30·060	+·004
December..	29·994	29·943	29·921	30·012	30·017	29·935	30·072	29·984	−·072
Yearly means.	30·040	30·032	30·036	30·048	30·081	30·073	30·081	30·056	

While Tables XIII. and XVIII. show a decreasing vapour-pressure and humidity, Table XXIII. shows an increasing atmospheric pressure. Hence the gaseous pressure has also been increasing.

The gradual diminution both of the vapour-pressure and humidity may be due to the clearings which have been extensively carried on in the interior of the island during the last fifteen or twenty years. It would be easy to attribute the change to *some general* cause affecting the surrounding ocean, but there seems to be no necessity for having recourse to that supposition when we know that forests must act as preservers of moisture, and that the forests of Mauritius have been rapidly disappearing. If observations had been taken at localities where forests existed, before and after they were cut down, the change would doubtless be much more marked than at Port Louis.

As to an increase of the atmospheric and gaseous pressures, with a decrease of vapour-pressure, that is in accordance with a general law.

The following are the means of the atmospheric and dry pressures for consecutive periods of two years each:—

Years.	Atmospheric Pressure.	Dry Pressure.
1860–61	30·036	29·369
1862–63	30·042	29·385
1864–65	30·077	29·428

These results are no doubt partly due to the disturbing action of hurricanes.

TABLE XXIV.—Showing the Maximum and Minimum Readings and the Extreme Range of the Barometer for each Month, from 1860 to 1866, both inclusive.

Months.		1860.	1861.	1862.	1863.	1864.	1865.	1866.	Monthly means.
		in.	in.	in.	in.	in.	in.	in.	in.
January	Maximum	29·991	30·011	30·029	30·081	30·085	30·142	30·107	30·063
	Minimum	29·542	29·544	29·745	29·231	29·706	29·875	29·748	29·627
	Range ...	0·449	0·467	0·284	0·850	0·379	0·267	0·359	0·436
February	Maximum	29·996	29·986	30·039	30·013	30·107	30·037	30·044	30·032
	Minimum	29·520	29·009	29·730	29·329	29·693	29·511	29·746	29·505
	Range ..	0·476	0·977	0·309	0·684	0·414	0·526	0·298	0·527
March ..	Maximum	30·059	30·083	30·150	30·065	30·096	30·088	30·072	30·088
	Minimum	29·454	29·282	29·750	29·734	29·667	29·757	29·836	29·640
	Range ...	0·605	0·801	0·400	0·331	0·429	0·331	0·236	0·448
April......	Maximum	30·131	30·109	30·117	30·123	30·094	30·071	30·132	30·111
	Minimum	29·834	29·897	29·898	29·755	29·859	29·871	29·820	29·848
	Range ...	0·297	0·212	0·219	0·368	0·235	0·200	0·312	0·263
May	Maximum	30·190	30·127	30·185	30·229	30·209	30·218	30·227	30·198
	Minimum	29·848	29·893	29·947	29·953	29·963	29·941	29·882	29·918
	Range ...	0·342	0·234	0·238	0·276	0·246	0·277	0·345	0·280
June	Maximum	30·297	30·246	30·255	30·282	30·335	30·400	30·295	30·301
	Minimum	29·969	29·945	29·863	30·048	30·069	29·971	29·988	29·979
	Range ...	0·328	0·301	0·392	0·234	0·266	0·429	0·307	0·322
July	Maximum	30·384	30·253	30·300	30·310	30·356	30·382	30·313	30·328
	Minimum	30·051	29·977	30·025	30·007	30·077	30·111	30·015	30·038
	Range ...	0·333	0·276	0·275	0·303	0·279	0·271	0·298	0·290
August ...	Maximum	30·245	30·304	30·337	30·323	30·373	30·355	30·340	30·325
	Minimum	29·954	30·016	30·065	30·087	30·063	30·073	30·004	30·037
	Range ...	0·291	0·288	0·272	0·236	0·310	0·282	0·336	0·288
September	Maximum	30·240	30·279	30·259	30·279	30·385	30·375	30·358	30·311
	Minimum	29·963	30·006	30·062	29·988	30·137	29·964	30·009	30·018
	Range ..	0·277	0·273	0·197	0·291	0·248	0·411	0·349	0·293
October...	Maximum	30·186	30·208	30·265	30·273	30·311	30·288	30·257	30·255
	Minimum	29·930	29·951	30·053	29·859	30·014	29·823	30·008	29·948
	Range ...	0·256	0·257	0·212	0·414	0·297	0·465	0·249	0·307
November	Maximum	30·164	30·076	30·124	30·147	30·199	30·231	30·230	30·167
	Minimum	29·938	29·844	29·826	29·925	29·933	29·962	29·986	29.916
	Range ...	0·226	0·232	0·298	0·222	0·266	0·269	0·244	0·251
December	Maximum	30·048	30·018	30·029	30·111	30·119	30·081	30·202	30·087
	Minimum	29·878	29·773	29·564	29·915	29·936	29·650	29·709	29·775
	Range ...	0·170	0·245	0·465	0·196	0·183	0·431	0·493	0·312
Means for years ...	Maximum	30·161	30·142	30·174	30·186	30·222	30·222	30·215	30·189
	Minimum	29·823	29·765	29·877	29·820	29·926	29·876	29·896	29·854
	Range ...	0·338	0·377	0·297	0·366	0·296	0·346	0·319	0·335

TABLE XXV.—Showing the Greatest and Least Readings (corrected and reduced) of the Barometer, the Dates, and Range in each Year.

Years	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Means.
Maximum	30·327	30·334	30·337	30·323	30·385	30·400	30·358	30·352
Dates	25th June.	26th Aug	15th Aug.	15th Aug.	22nd Sept.	30th June.	9th Sept.	12th Aug.
Minimum	29·454	29·009	29·564	29·231	29·667	29·511	29·630	29 438
Dates	24th March.	15th Feb.	2nd Dec.	13th Jan.	4th March	12th Feb.	7th Dec.	28th Jan.
Range	0·873	1 325	0 773	1 092	0·718	0·889	0·728	0·914

TABLE XXVI.—Showing the Number of times the Wind blew from the principal points of the Compass during each Year, from 1861 to 1865 inclusive.

Direction.	1861.	1862.	1863.	1864.	1865.	Totals.
North	26	14	12	5	12	69
North to N.E.	14	14	8	8	3	47
N.E.	19	14	15	14	11	73
N E. to East	173	88	95	66	72	494
East	395	226	209	288	162	1280
East to S.E.	203	376	366	403	455	1803
S.E.	136	227	281	268	291	1203
S.E. to South	57	80	102	82	133	454
South	8	8	4	9	10	39
South to S.W.	5	3	6	5	6	25
S.W.	6	5	4	7	10	32
S.W. to West	12	19	13	12	6	62
West	28	31	21	22	9	111
West to N.W.	29	30	40	34	43	176
N.W.	14	27	38	37	33	149
N.W. to North	19	21	32	18	19	109
Calm	233	271	207	181	184	1076
Variable	83	6	7	1	1	98
Totals	1460	1460	1460	1460	1460	7300

TABLE XXVII.—Showing the Mean Estimated Force of the Wind, in Pounds' Pressure on the Square Foot, for each Observation Hour, derived from Six-hourly Observations, taken daily during Seven Years (1860–1866).

Hours.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Means.
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
3½ A.M.	0·74	0·55	0·23	0·38	0·27	0·31	0·35	0·41
9½ A.M.	0·86	0·59	0·36	0·43	0·34	0·32	0·37	0·48
3½ P.M.	0·76	0·53	0·31	0·47	0·33	0·34	0·42	0·45
9½ P.M.	0·72	0·49	0·29	0·37	0·25	0·33	0·30	0·39
Yearly means	0·77	0·54	0·30	0·41	0·30	0·32	0·36	0·43

TABLE XXVIII.—Showing the Mean Estimated Force of the Wind for each Month, in Pounds' Pressure on the Square Foot, as derived from Six-hourly Observations, taken daily during Seven Years (1860–1866).

Months.	1860.	1861	1862.	1863.	1864.	1865.	1866.	Monthly means.
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
January	1·12	0·57	0·44	0·48	0·27	0·32	0·34	0·51
February	1·25	0·72	0·99	1·71	0·25	0·57	0·23	0·82
March	0·71	1·72	0·56	0 18	0·24	0·32	0·21	0·56
April	0·62	0·50	0·12	0·27	0·29	0·20	0·64	0·38
May	1·12	0·29	0·15	0·34	0·23	0·28	0·28	0·38
June	0·82	0·63	0·14	0·50	0·42	0·47	0·45	0·49
July	0·77	0·46	0·18	0·34	0·33	0·36	0·42	0·41
August	0·60	0·68	0·20	0·40	0·35	0·35	0·42	0·43
September	0·54	0·29	0·16	0·24	0·45	0·27	0·48	0·35
October	0·69	0·17	0·19	0·19	0·28	0·26	0·33	0·30
November	0·53	0·24	0·21	0·12	0·21	0 24	0·26	0·26
December	0·35	0·26	0·23	0·16	0·27	0·29	0·27	0·26
Yearly means	0·76	0·54	0·29	0·41	0·30	0·33	0·36	0·43

The general accordance of the results in Tables XXVIII. and XXIX. is evident, both showing two maxima in February and June, and two minima in April and November. The discrepancy in the amount of force is due to the results in the former Table having been derived from four daily observations of the *estimated* force during seven years, while the results in the latter have been obtained by taking the means of the daily *maximum* force recorded by Osler's anemometer during six years.

TABLE XXIX.—Showing the Mean Maximum Force of the Wind for each Month, during Six Years, in Pounds' Pressure on the Square Foot, as obtained by Osler's Anemometer.

Months.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Monthly means.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
January	4·00	2·10	0·93	2·20	0·76	1·10	1·13	1·69
February ...	3·00	10·69	2·85	4·46	0·93	1·88	0·63	2·29
March	2·00	Anemometer broken.	2·28	0·38	0·53	1·59	0·63	1·23
April	1·85		0·29	1·35	0·51	0·78	2·49	1·21
May	3·44		0·99	1·79	0·66	1·34	1·31	1·59
June	4·70		0·37	2·34	2·48	2·52	2·48	2·48
July	2·60		1·56	2·08	2·23	2·28	2·05	2·13
August	2·50		1·15	1·96	2·34	2·60	2·20	2·12
September ...	2·50		0·50	0·85	2·50	1·79	2·06	1·70
October	2·34		0·68	0·50	0·95	0·83	0·84	1·02
November .	1·95		0·91	0·27	0·94	0·71	0·42	0·87
December ..	2·35		0·65	0·40	0·85	1·03	0·49	0·96
Yearly means	2·77	.. ...	1·10	1·55	1·31	1·54	1·39	1·61

TABLE XXX.—Showing the Greatest Force of the Wind, in Pounds' Pressure on the Square Foot, and the Dates, in each Year.

Years	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Means.
Maximum force	lbs. 18·0	lbs. 40·0	lbs. 12·5	lbs. 36·0	lbs. 8·7	lbs. 13·5	lbs. 13·5	lbs. 20·3
Date	21st June.	15th Feb.	26th Feb.	20th Feb.	2nd July.	21st Feb.	16th April.	5th April.

TABLE XXXI.—Showing the Mean Estimated Extent of Cloud for each Observation Hour, as derived from Six-hourly Observations taken daily during Seven Years (1860–66), 10 being taken for an entirely overcast sky, and 0 for an entirely cloudless sky.

Hours.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Means.
3½ A.M.	4·1	4·0	2·9	3·0	3·6	4·0	4·3	3·7
9½ A.M.	6·0	5·7	5·1	5·5	5·6	5·9	5·7	5·6
3½ P.M.	6·7	6·1	5·8	5·7	6·3	6·4	6·3	6·2
9½ P.M.	4·0	3·5	3·0	3·0	3·5	3·7	3·8	3·5
Means	5·2	4·8	4·2	4·3	4·7	5·0	5·0	4·7

TABLE XXXII.—Showing the Mean Extent of Cloud, in each Month and Year, from 1860 to 1866, both inclusive, 10 being taken for an entirely overcast sky, and 0 for an entirely cloudless sky.

Months.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Monthly means.
January	6·0	5·8	5·3	4·7	5·1	4·6	6·1	5·4
February	6·7	6·9	5·3	7·1	6·1	5·5	5·1	5·9
March	4·6	5·3	4·5	5·8	4·0	5·9	4·7	4·9
April	4·4	5·0	3·4	4·0	5·2	3·8	5·6	4·5
May	4·9	5·2	3·9	2·9	4·0	4·3	4·9	4·3
June	4·6	4·2	2·8	3·1	3·8	5·1	4·5	4·0
July	5·9	4·1	3·5	4·2	4·5	4·1	4·2	4·3
August	4·6	4·3	4·2	3·5	4·9	5·4	4·8	4·9
September	4·9	3·9	3·8	3·9	4·9	4·1	4·9	4·3
October	5·8	3·7	5·7	4·5	4·2	5·5	6·3	5·1
November	4·8	4·2	4·2	3·2	5·2	4·3	4·2	4·3
December	5·7	4·5	3·7	4·8	5·0	7·3	4·9	5·1
Yearly means	5·2	4·8	4·2	4·3	4·7	5·0	5·0	4·7

TABLE XXXIII.—Showing the Amount of Rainfall, in inches, for each Month and Year, from 1860 to 1866, both inclusive.

Months.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Monthly means.	Deviation from mean.
	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	14·65	5·37	4·02	9·48	2·32	3·27	5·41	6·36	+ 3·20
February	13·55	46·57	4·69	10·95	5·75	15·54	2·54	14·23	+11·07
March	7·58	2·48	5·97	3·43	2·99	3·17	3·81	4·20	+ 1·04
April	1·25	3·23	1·84	1·49	1·92	0·77	4·78	2·18	− 0·98
May	1·33	3·73	6·76	0·71	0·51	0·22	1·16	2·06	− 1·10
June	0·45	0·87	0·58	1·71	0·31	0·78	0·37	0·72	− 2·44
July	0·85	0·45	0·60	0·73	1·47	2·35	0·36	0·97	− 2·19
August	2·18	1·84	1·09	0·29	3·94	3·28	0·73	1·91	− 1·25
September	0·38	0·00	0·31	0·72	0·37	0·60	0·37	0·39	− 2·77
October	0·53	0·03	0·59	1·18	0·83	0·82	0·24	0·60	− 2·56
November	0·16	2·15	0·81	0·35	1·90	1·84	0·00	1·03	− 2·13
December	2·27	2·04	1·13	2·37	1·83	12·09	0·79	3·22	+ 0·06
Fall for year	45·18	68·76	28·39	33·41	24·14	44·73	20·56	37·87	
Deviation from mean	+7·31	+30·89	−9·48	−4·46	−13·73	+6·86	−17·31	3·16	

The rain-gauge is 40 feet above the ground; the mouth of the receiver is 20 by 10 inches; and the rain is conducted by a leaden tube to a room in the Observatory.

TABLE XXXIV.—Showing the Greatest Rainfall, in inches, on any one day, in each Year, with the Date.

Years.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Means.
Greatest rainfall in 24 hours	in. 5·82	in. 10·00	in. 3·25	in. 3·17	in. 2·45	in. 7·46	in. 1·72	in. 4·84
Date	26th Jan.	15th Feb.	25th May	13th Jan.	11th Feb.	12th Feb.	24th Mar.	26th Feb.

TABLE XXXV.—Showing the Annual Rainfall, in inches, at different Stations in Mauritius, from 1862 to 1866, both inclusive.

Stations.	1862.	1863.	1864.	1865.	1866.	Means.
	in.	in.	in.	in.	in.	in.
Flat Island	28·02	36·54	......	......	......	......
Gros-Cailloux	25·35	33·35	24·17	36·57	20·72	28·03
Port Louis............	28·39	33·41	24·14	44·73	20·56	30·24
Mont Choisy	41·56	54·66	48·89	67·53	45·05	51·54
Les Rochers	41·84	64·27	42·65	60·95	40·81	50·10
Botanical Gardens...	......	......	51·55	85·37	......	......
Labourdonnais	52·23	70·72	57·25	87·63	50·29	63·62
Lucia	60·71	67·87	57·94	101·56	51·84	67·98
Croft-an-Righ	......	......	56·61	79·44	40·68	......
Beau Séjour	69·07	99·76	56·60	87·12	44·56	71·42
Trianon	......	80·66	48·58	81·19	43·24	......
The Braes	59·51	81·09	70·59	78·77	48·70	67·73
Mesnil	......	......	......	......	67·67	......
Espérance	......	......	......	147·74	88·02	......
La Gaieté	......	......	......	97·55	57·77	......
Cluny	122·54	147·09	122·48	192·45	129·42	142·80
Gros Bois	......	......	83·36	135·21	70·24	......
Beau Vallon	......	......	......	100·85	51·05	......
St. Aubin	......	......	......	115·61	70·51	......

It may be proper to mention that, with the exception of Port Louis, Mont Choisy, Les Rochers, the Botanical Gardens, Labourdonnais, Mesnil, and La Gaieté, all the stations are supplied with rain-gauges of the same form and size, viz., Glaisher's rain-gauge as made by Negretti and Zambra. Except at Port Louis and La Gaieté the gauges are placed on the ground.

TABLE XXXVI.—Showing the number of Days on which Lightning was seen, or Thunder heard, in each Month and Year, from 1860 to 1866, both inclusive.

Months.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Means.
January	9	10	8	11	6	......	2	6·6
February	1	2	4	9	7	11	8	6·0
March	10	....	2	13	2	3	10	5·9
April	3	2	4	6	10	2	5	4·6
May	.....	3	1	....	5	2	1	1·7
June	......	.....	.....	.....	..	..	.	....
July	......	....	.....	...	...	.	....	....
August	.....	...	...	....	1	...	...	0·1
September	......	.....	...	...	......	.	..	....
October	...	....	...	...	......	..	......	....
November	.....	1	.....	1	2	2	...	0·8
December	1	2	.....	......	......	2	......	0·7
Totals	24	20	19	40	33	22	26	26·4

TABLE XXXVII.—Showing the Mean Values of the principal Meteorological Elements for each Observation Hour, derived from Six-hourly Observations taken daily during Seven Years (1860–66).

Hours.	Temperature of air.	Atmospheric pressure.	Vapour-pressure.	Dry pressure.	Humidity 100—0.	Estimated force of wind, in lbs.	Amount of cloud 10—0.
	°	in.	in.	in.		lb.	
$3\frac{1}{2}$ A.M. ...	75·50	30·038	·646	29·392	73·7	0·41	3·7
$9\frac{1}{2}$ A.M. ...	77·59	30·086	·654	29·432	70·0	0·48	5·6
$3\frac{1}{2}$ P.M. ...	78·99	30·015	·658	29·357	67·3	0·45	6·2
$9\frac{1}{2}$ P.M. ...	76·36	30·085	·652	29·433	72·6	0·39	3·5
Means ...	77·11	30·056	·652	29·404	70·9	0·43	4·7

It appears from Table XXXVII. that the march of the dry pressure is similar to that of the total or atmospheric pressure, the rise and fall for both being as follows:—

Period.	Total Pres.	Dry Pres.
$3\frac{1}{2}$ A.M. to $9\frac{1}{2}$ A.M.	+·048	+·040
$9\frac{1}{2}$ A.M. to $3\frac{1}{2}$ P.M.	—·071	—·075
$3\frac{1}{2}$ P.M. to $9\frac{1}{2}$ P.M.	+·070	+·076
$9\frac{1}{2}$ P.M. to $3\frac{1}{2}$ A.M.	—·047	—·041

TABLE XXXVIII.—Showing the Means of the principal Meteorological Elements for each Hour of the Day, derived from Hourly Observations taken on the 21st of every Month, from 1863 to 1866, both inclusive.

Hours.	Temperature of air.	Atmospheric pressure.	Vapour-pressure.	Dry pressure.	Humidity 100—0.	Estimated force of wind.
	°	in.	in.	in.		lb.
6 A.M. ...	75·55	30·060	·628	29·432	69·8	0·20
7 „ ...	75·77	30·071	·633	29·438	69·8	0·30
8 „ ...	76·54	30·082	·642	29·440	69·5	0·18
9 „ ...	77·11	30·090	·640	29·450	67·6	0·25
10 „ ...	78·12	30·087	·644	29·443	66·0	0·30
11 „ ...	78·92	30·075	·645	29·430	65·0	0·31
Noon	79·18	30·059	·644	29·415	63·9	0·30
1 P.M. ...	79·43	30·039	·646	29·393	63·6	0·30
2 „ ...	79·36	30·025	·646	29·379	64·0	0·40
3 „ ...	79·22	30·017	·644	29·373	63·9	0·26
4 „ ...	78·86	30·020	·634	29·386	63·8	0·25
5 „ ...	78·22	30·030	·636	29·394	65·1	0·25
6 „ ...	77·61	30·044	·634	29·410	66·3	0·22
7 „ ...	77·08	30·060	·633	29·427	67·4	0·30
8 „ ..	76·76	30·074	·634	29·440	68·1	0·23
9 „ ...	76·46	30·084	·634	29·450	68·6	0·18
10 „ ...	76·31	30·086	·632	29·454	68·9	0·17
11 „ ...	76·19	30·081	·631	29·450	69·1	0·19
Midnight..	75·96	30·072	·629	29·443	69·3	0·19
1 A.M. ...	75·89	30·059	·630	29·429	69·7	0·23
2 „ ...	75·82	30·047	·629	29·418	69·9	0·25
3 „ ...	75·72	30·039	·625	29·414	69·6	0·23
4 „ ...	75·71	30·037	·621	29·416	69·0	0·26
5 „ ...	75·59	30·043	·623	29·420	69·6	0·20
Daily means ...	77·14	30·057	·635	29·422	67·4	0·25

TABLE XL *.—Showing the Means of the Extreme Range of the principal Meteorological Elements for each Month, derived from Six-hourly Observations taken daily from 1860 to 1866, both inclusive.

Months.	Temperature of air.	Atmospheric pressure.	Vapour-pressure.	Humidity 100—0.
	°	in.	in.	
January	12·55	0·436	·265	30·9
February	12·36	0·527	·250	31·9
March	11·83	0·448	·270	29·0
April	12·80	0·263	·268	26·8
May	13·53	0·280	·276	27·9
June	12·67	0·322	·268	28·2
July	10·78	0·290	·222	28·0
August	11·36	0·288	·221	30·4
September	11·80	0·293	·213	26·8
October	11·36	0·307	·233	27·9
November	13·09	0·251	·229	27·3
December	13·59	0·312	·237	28·8
Yearly means	12·29	0·335	·246	28·7

* Tables XXXIX. and XL. have been transposed in order to save space.

TABLE XXXIX.—Showing the Monthly Means of the Meteorological Elements, derived from Six-hourly Observations taken daily from 1860 to 1866, both inclusive.

Months.	Temperature of air.	Mean maximum temperature in sun's rays.	Atmospheric pressure.	Vapour-pressure.	Dry pressure.	Humidity. 100—0.	Wind. Mean maximum force.	Wind. Mean force (estimated).	Wind. Prevailing direction.	Amount of cloud 10—0.	Rainfall, in inches.	Lightning or thunder, number of days.
	°	°	in.	in.	in.		lb.	lb.			in.	
January	81·72	117·6	29·927	·759	29·163	71·9	1·69	0·51	E.S.E. to N.E.	5·4	6·36	6·6
February ..	81·26	115·3	29·843	·767	29·076	74·7	2·29	0·82	E S.E. to N.E.	5·9	14·23	6·0
March	80·64	115·7	29·934	·743	29·191	72·8	1·23	0·56	E.S E. to E.N.E	4·9	4·20	5·9
April	79·87	113·1	29·996	·713	29·283	71·6	1·21	0·38	E S.E. to E.N.E.	4·5	2·18	4·6
May	76·45	106·1	30·070	·637	29·433	71·0	1·59	0·38	E.S.E. to E.	4·3	2·06	1·7
June	73·46	102·8	30·157	·572	29·585	70·3	2·48	0·49	S.E. to E.	4·0	0·72	
July	71·95	101·2	30·191	·550	29·641	70·6	2·13	0·41	S E. to E.	4·3	0·97	
August	72·21	104·0	30·193	·562	29·631	71·6	2·12	0·43	S.E. to E.	4·9	1·91	0·1
September ..	73·12	107·3	30·186	·558	29·628	69·2	1·70	0·35	S.E. to E.	4·3	0·39	
October ..	75·22	112·3	30·129	·596	29·533	68·9	1·02	0·30	E.S.E. to E.	5·1	0·60	
November ...	78 62	115·0	30·060	·655	29·405	68·1	0·87	0·26	E.S.E. to E.	4·3	1·03	0·8
December .	80·79	115·8	29·984	·719	29·265	70 0	0·96	0·26	E.S.E. to E.N.E	5·1	3·22	0·7
Yearly means	77 11	110·5	30 056	·652	29·404	70·9	1·61	0·43	E S E. to E.	4·7	37·87	26·4

TABLE XLI.—Showing the Highest and Lowest Values, and the Extreme Ranges, of the principal Meteorological Elements for each Year, from 1860 to 1866, both inclusive, with the Epochs of Maximum and Minimum.

Observations.		1860.	1861.	1862.	1863.	1864.	1865.	1866.	Annual means.
Temperature of air.	Highest ..	88·1	88·0	89·4	88·0	89·0	90·0	89·0	88·77
	Date ...	31st Jan.	14th Jan.	27th Dec.	23rd Jan.	2nd Dec.	4th Feb.	1st April.	23rd Jan.
	Lowest ...	66·5	67·0	68·0	65·9	66·0	67·6	62·8	66·25
	Date ...	22nd June	11th Sept.	24th June	8th July.	2nd Aug.	10th July.	29th Aug.	24th July.
	Range......	21·6	21·0	21·4	22·1	23·0	22·4	26·2	22·52
Atmospheric pressure.	Highest ...	30·327	30·334	30·337	30·323	30·385	30·400	30·358	30·352
	Date ...	25th June.	26th Aug.	15th Aug.	15th Aug.	22nd Sept.	30th June.	9th Sept.	12th Aug.
	Lowest ...	29·454	29·009	29·564	29·231	29·667	29·511	29·630	29·438
	Date ...	24th Mar.	15th Feb.	2nd Dec.	13th Jan.	4th Mar.	12th Feb.	7th Dec.	28th Jan.
	Range......	0·873	1·325	0·773	1·092	0·718	0·889	0·728	0·914
Vapour-pressure.	Highest ..	0·914	0·896	0·903	0·955	0·868	0·940	0·940	0·916
	Date ...	29th Jan.	31st Jan.	27th Jan.	19th Jan.	6th Mar.	19th Feb.	21st. Feb.	8th Feb.
	Lowest ...	0·446	0·449	0·450	0·400	0·408	0·435	0·367	0·421
	Date ...	20th June.	19th June.	15th June.	20th July.	31st July.	12th Aug.	27th Sept.	21st July.
	Range......	0·467	0·447	0·453	0·555	0·460	0·505	0·573	0·495
Humidity.	Highest ...	96·7	95·3	90·9	90·7	90·7	90·9	91·0	92·31
	Date ...	21st Aug.	16th Feb.	9th Feb.	5th April.	12th Aug.	12th Feb.	4th Jan.	8th April.
	Lowest ..	50·3	46·3	53·3	52·8	52·5	52·5	48·0	50·81
	Date ...	7th Oct.	10th June.	17th Nov.	1st Nov.	11th July.	12th Aug.	26th July.	29th Aug.
	Range......	46·4	49·0	37·6	37·9	38·2	38·4	43·0	41·5
Maximum force of wind in pounds pressure on square foot		18·0	40·0	12·5	36·0	8·7	13·5	13·5	20·31
	Date ...	21st June.	15th Feb.	26th Feb.	20th Feb.	2nd July.	21st Feb.	16th April.	5th April.
Greatest rainfall in twenty-four hours ...		5·82	10·00	3·25	3·17	2·45	7·46	1·72	4·84
	Date ...	26th Jan.	15th Feb.	25th May.	13th Jan.	11th Feb.	12th Feb.	24th Mar. & 3rd Apr.	26th Feb.

TABLE XLII.—Showing the Means of the principal Meteorological Elements for each Year, derived from Six-hourly Observations taken daily from 1860 to 1866, both inclusive.

Years.	Temperature of air.	Temperature in sun's rays.	Atmospheric pressure.	Vapour-pressure.	Dry pressure.	Humidity 100—0.	Wind.		Amount of cloud 10—0.	Rainfall, in inches.	Lightning or thunder, number of days.
							Mean maximum force.	Mean force (estimated).			
	°	°	in.	in.	in.		lb.	lb.		in.	
1860	77·17	112·9	30·040	·680	29·360	73·6	2·77	0·76	5·2	45·18	24
1861	76·90	110·4	30·032	·655	29·377	71·7	....	0·54	4·8	68·76	20
1862	77·67	110·9	30·036	·663	29·373	71·2	1·10	0·29	4·2	28·39	19
1863	77·10	109·9	30·048	·652	29·396	71·1	1·55	0·41	4·3	33·41	40
1864	76·72	109·5	30·081	·643	29·438	70·8	1·31	0·30	4·7	24·14	33
1865	77·10	109·9	30·073	·655	29·418	71·2	1·54	0·33	5·0	44·73	22
1866	77·14	110·1	30·081	·619	29·462	66·4	1·39	0·36	5·0	20·56	26
Yearly means	77·11	110·5	30·056	·652	29·404	70·9	1·61	0·43	4·7	37·87	26·4

On the Construction and Works of the Highland Railway. By Joseph Mitchell, *F.R.S.E., F.G.S., C.E., and Member of the Institution of Civil Engineers.*

This title represents the union of several Companies in the north of Scotland, amalgamated three years ago under the name of the Highland Railway Company. The works consist of a main line from a point near Perth, extending northward 117 miles to the town of Forres, and a base-line running nearly at right angles to the other, extending westwards from the town of Keith by Elgin and Forres along the shores of the Moray Firth to Inverness, and thence along the Beauly, Dingwall, and Dornoch Firths, northwards to Bonar Bridge, measuring from Keith to Inverness 55 miles, and from Inverness to Bonar Bridge 58 miles, and making together a base-line of 113 miles. These railways traverse the northern part of Perthshire, and are the main lines of communication through part of Banffshire and the counties of Inverness, Nairn, Moray, and Ross, the whole including three branches—two to the ports of Burghead and Findhorn in Morayshire, and the other to the village of Aberfeldy in Perthshire—and extending to 246 miles length.

The country is fertile and comparatively flat for a distance of about 40 miles north of Perth, and also along the shores of the Moray, Dingwall, and Dornoch Firths; but between Perthshire and Morayshire the line crosses two ranges of the Grampian Mountains, the one separating the valley of the Tay from that of the Spey, and the northern range separating the Spey from the valley of the Findhorn.

The large rivers which drain these mountain-regions debouch into the Tay, the Moray, the Dingwall, and the Dornoch Firths, and as the railway in most cases crosses these rivers near the sea, bridges of considerable magnitude were required. Besides the crossing of these rivers, other difficulties of a formidable character arose in crossing the mountains at so great an elevation, and in passing the rocky and precipitous defiles through which portions of the line had to run.

The northern counties traversed by these railways, except along the shores of the Firths, are chiefly pastoral, exporting large numbers of sheep and cattle.

The fisheries also are on an extensive scale; besides the salmon fisheries in the rivers, the annual take of white fish in the Moray Firth amounts to about 60,000 tons.

The object of the promoters, therefore, was to sweep the fertile shores of the Moray Firth, and to send the produce of the country by the most direct route to Perth, across the mountains, thus saving a detour by Aberdeen of nearly 60 miles. In laying out the main line and crossing the Grampians between Perth and Forres, long and steep inclines could not be avoided, but there is no steeper gradient than 1 in 70 throughout. The line to Blair, 36 miles from Perth, rises only 443 feet above the level of the sea, but from Blair to the summit of the southern range of the Grampians, a distance of 17 miles, the line rises 1045 feet, making the extreme summit 1488 feet above the sea. In this distance there are gradients for 10 continuous miles of 1 in 72 and 1 in 70, and in the remaining 7 miles the inclines vary from 1 in 78 to 1 in 110. After passing this summit the line descends into the valley of the Spey, falling 747 feet in 18 miles, the steepest gradient being 1 in 80. On crossing the Spey, the line is comparatively level for a distance of 24 miles, when it again ascends by gradients of 1 in 84, 80, and 100, in order to pass the northern ridge which separates the valley of the Spey from that of the

Findhorn. This summit is 1046 feet above the sea-level. It afterwards descends to Forres (the point of junction with the base-line) by gradients, the steepest of which are 1 in 70 for 8 miles, and 1 in 76 for 4 miles.

In this length of the main direct line of 104 miles, there are two small tunnels, one of 350 yards near Dunkeld, and the other in the Pass of Killiecrankie of 110 yards in length, both constructed very much with the view of avoiding injury to the adjoining scenery.

The principal difficulties that arose in laying out the line were in passing through the narrow defile at Dunkeld, the beautiful demesne of the Duke of Athole, and again in penetrating through the picturesque Pass of Killiecrankie, where the mountains, as it were, close in upon each other for a great height; likewise in passing along the narrow, precipitous, and rocky valley of the Garry, close to a large and rapid mountain-stream; also the Park at Castle Grant, and the defile at Huntley's Cave near Grantown. These points in particular required much study, with repeated trial and contour levels, so as to obtain a knowledge of the precise formation of the ground, and to choose the best direction at the lowest possible cost. At the Pass of Killiecrankie the banks were so precipitous and steep that the line had to be supported by breast or retaining walls to the extent of 690 lineal yards, and to the average height of 26 feet, the extreme height of one being 55 feet: and in order to carry the railway at the narrowest point in the Pass where the precipices close in, as it were, on either side, and afford scarcely any additional space beyond that occupied by the channel of the river, instead of supporting the line by breastwalls, it was deemed prudent to construct a viaduct of 10 arches, 60 feet above the river, which with a tunnel at the north end carries it successively through the Pass. At two other points on the line, in running up the sides of the Garry, breastwalls had to be formed, respectively 94 and 35 yards in length, and 15 feet in average height. All these breastwalls, extending to 1650 lineal yards, are built with lime, and set on a solid foundation of dry gravel or rock, at right angles to the face of the wall, which batters at the rate of $1\frac{1}{2}$ inch to the foot.

The spaces behind the walls are filled with rubble stones. set by hand for 10 feet wide, and further back with dry gravel, it being important that all earth or clayey substances should be excluded. The writer prefers the curved to the straight batter, as it gives more effectual resistance if well built; but breastwalls are to be avoided wherever earth embankments can be substituted, as, in his experience, there are subtle influences in the Scottish climate of alternate frost and wet in winter, which operate imperceptibly to their destruction, and they require careful and constant inspection. Except where those breastwalls became necessary, the whole of the lines were formed in cuttings and embankments, and for considerable distances along the slopes of valleys. Where the ground was precipitous or irregular in the cross section, level benchings were formed, 10 feet in width, immediately underneath the permanent way, in order that the sleepers should have an equal and solid bearing throughout.

In running through so large an extent of mountainous country, the line, as might be expected, had to pass over some lengths of soft ground and morass. The principal of these were for two miles near the town of Nairn, also for about two miles near Keith, one mile on Dava Moor, and about a mile in crossing through a hollow at Drumochter on the summit of the Grampians. In all places where the ground was particularly soft, a uniform mode of treatment was adopted. Two parallel drains were first cut outside the fences, about 50 feet apart, from 4 to 6 feet deep, and with slopes of 1

to 1. This drained off the surface-water; and, after making up the holes and other irregularities of the surface with turf, the space for the railway to a breadth of about 15 feet was covered with two or three layers of swarded or heather turf, having the sward side of the lower layer undermost, and that of the top layer up, the joints breaking band. In this way a good sustaining surface has uniformly been obtained*. On this bed of turf the ballast was laid for 2 or 3 feet in depth. This was quite sufficient to support the traffic, but as in some cases the bed of moss was from 20 to 30 feet in depth, the railway merely floated on the surface, and was in the first instance undulating, and yielded in some parts from 3 to 4 inches under the weight of the engines passing over. To obviate this undulation longitudinal beams of timber were tried at one place, 30 to 40 feet long, below the sleepers, but this was found objectionable, as rendering it more difficult to raise or repair the surface of the road; and an additional sleeper (making the sleepers 2 feet 6 inches from centre to centre, instead of 3 feet) was found preferable. There was nothing for it, at the worst, but to lift the road every other week as it sunk, until it had acquired a solid bearing. In many places we had to lay on 4, 5, or 6 feet in depth of additional gravel, and in one place no less than 27 feet, before the road became solid. In the course of two or three years, however, with due attention, the rails being fished, the lines through these mosses were all that could be desired for solidity and permanence.

As the writer has said, in crossing so many mountain-rivers, bridges of magnitude had to be constructed, involving considerable varieties of execution. The principal of these bridges may now be described, and any peculiarity will be noticed which may have arisen during the progress of the works. It will be observed that the beds of the rivers in the north of Scotland differ in many respects from what is common in England, consisting frequently of depths of 10 or 12 feet of gravel and boulders, the solid and compacted débris of successive floods, below which, if the country is of rocky formation, there is usually hard clay, and then rock, or, as in one case at the mouth of the River Ness, after penetrating 12 feet of shingle and boulders, a sort of admixture of whitish clay and sand was obtained. In some cases we had to deal with soft clay and mud of great depth, but these were exceptions. Nor was it possible in general to ascertain, by boring, the precise nature of the foundations, because many of the boulders in the gravel were of large size, and were often mistaken for rock. The only way in which an approximate knowledge of the foundations could be obtained was by driving iron rods at various places, and, when the bed of the river admitted of it, wooden piles. Still we worked very much in the dark; but the writer's long experience of these rivers, and of the nature of their floods, was of great advantage in enabling him to fix the depth of the foundations and the precise description of works, to secure the necessary stability of construction. In only two or three cases was there any fear of sinking. What had chiefly to be guarded against was sudden and impetuous floods, sometimes accompanied with floating ice and trees, undermining the foundations and damaging the piers; it was therefore important to provide ample waterway. The construction of these bridges ranged over twelve years, and during that time there has been considerable changes in bridge building, by the adoption of iron cylinders for piers, and lattice girders in spanning the waterways, so that, as the works progressed, these improvements were adopted where found suitable.

* Had this plan, which the writer has found to answer so well both for roads and railways, been adopted in the clayey ground at Balaklava in the Crimea, a good road might have been formed.

In planning these works, the writer, while having every regard to economy, felt the importance of their being of the most substantial character, seeing that they were exposed in these districts to every vicissitude of climate and flood; but indeed he feels that all permanent public works involving the safety of the lives of the community should be of undoubted stability. On the whole system there are only three timber bridges, which he was forced to adopt, chiefly with a view to save time, but these are very substantial of their kind. All the other bridges are constructed of stone, and where iron is adopted the piers are in general constructed of masonry.

The iron work of the bridges on all these lines were constructed by Messrs. Fairbairn and Sons of Manchester, for about £20 per ton on the average, and are admirable specimens of workmanship in this department.

Accompanying this paper, the writer furnished the working drawings of fourteen of these bridges, with the sections and dimensions in detail. They exhibit a variety of forms suited to the localities in which they are built.

No. 1 is an *iron-girder bridge across the Tay*, 6 miles north of Dunkeld, with stone abutments and pier, constructed on platforms and piles in the usual way. The banks are low, and the river is spanned by two openings, one of 210 feet, and the other of 141 feet. The cost of this work was £20,395. Extreme length 515 feet; height above the bed of the river 67 feet; cost per lineal foot £39 12*s.*

Nos. 2 and 3 are the most recent bridges erected by the writer; and here he has taken advantage of the modern plan of using cylinder piers to carry the girders. Both bridges are constructed in the same manner, and on the same principle. The cylinders form the piers in the centre and abutments. Each cylinder is 8 feet in diameter, and has been sunk into the bed of the river 27½ feet in their extreme depth, by means of divers. When these cylinders were adjusted and brought to the full depth, about 3 feet of cement concrete was lowered into the bottom. On the concrete setting, the water was pumped out, and the interior filled in with rubble masonry, laid with Portland cement. To provide for extreme floods, two side openings were made, 41½ and 35 feet span, of plate girders, one end resting on the masonry in the cast-iron cylinders, and the other on a stone abutment landward, secured on a platform and piles. These bridges answer their purpose very satisfactorily. The cost of No. 2 bridge, which consists of two openings of 122 feet, and two side openings of 35 feet span, was £11,156. Total length of No. 2 350 feet; cost per lineal foot £31 17*s.* 6*d.*; height above the bed of the river 36 feet.

The cost of No. 3 bridge, consisting of two openings of 137 feet span, and two side openings of 41½ feet span, the cylinders being sunk into the bed of the river 25 feet, amounted to £13,772. Length of No. 3, 419½ feet; cost £32 16*s.* 7*d.* per lineal foot; height above the bed of the river 49 feet.

No. 4 is the *viaduct* in *the Pass of Killiecrankie* already alluded to. It consists of 10 arches of 35 feet span, with an extreme height from the foundations to the top of the parapet of 54 feet, and is built with a curve of 20 chains radius. The Pass of Killiecrankie is a well-known object of picturesque beauty, and it is generally admitted that the railway, now that the slopes have attained their proper verdure, has in no way diminished its attractions. Indeed this viaduct is thought to give it additional interest. The cost was £5720. It is adapted to the single line, and is 17 feet in width over parapets. Length 508 feet; cost per lineal foot £11 5*s.*

No. 5 is a viaduct across the *River Tilt, near Blair Athole*, spanning the river by one wrought-iron girder of 150 feet. The abutments are of stone, laid three feet below the bed of the river on a platform of timber 6 inches

HIGHLAND RAILWAY.—Abstract note of the chief Viaducts on the Highland Railway.

Nos. on plans.	Situation.			Extreme length.	Height above the bed of the river.	Cost.	Cost per lineal foot.	Remarks.
				feet.	feet.	£	£ s. d.	
1	Viaduct over the River Tay at Dalguise.	Abutments and pier of stone.	2 spans of wrought iron 210 feet and 141 feet.	515	67	20.395	39 12 0	Built for a single line.
2	Viaduct over the River Tummel at Ballinling.	Piers of cast-iron cylinders.	2 spans of 122 feet each, and 2 of 35 feet.	350	36	11,156	31 17 6	" "
3	Viaduct over the River Tay at Logierait.	Piers of cast-iron cylinders.	2 spans of 137 feet each, and 2 of 41½ feet.	419½	49	13,772	32 16 7	" "
4	Killiecrankie Viaduct. ...	Stone and lime. ...	10 arches of 35 feet span ..	508	54	5,720	11 5 0	" "
5	Viaduct over the River Tilt at Blair Athole.	Abutments of stone.	1 span of wrought iron 150 feet.	256	40	6,500	25 7 9	" "
6	Viaduct over the River Garry at Calvine.	All stone and lime.	1 arch 80 feet span, 2 arches 40 feet span.	274	55	5,100	18 12 3	" "
7	Viaduct over the River Dulnain.	Stone abutments ...	1 wrought iron span of 80 feet.	148	27	3,298	22 5 6	" "
8	Viaduct over the River Divie.	All stone and lime.	7 arches of 45 feet span ...	477	106	10,231	21 9 0	" "
9	Viaduct over the River Spey near Keith.	....	1 span of 230 feet of wrought iron, and 6 side arches of stone and brick, each 30 feet span.	660	74	34,482	52 5 0	Double line.
10	Viaduct over the River Findhorn near Forres.	Stone abutments and piers.	3 spans of 150 feet each of wrought iron.	608½	46½	21,430	35 4 4	Single line.
11	Viaduct over the River Nairn at Nairn.	All stone	4 arches of 55 feet span	371	56	8,620	23 4 8	Double line.
12	Viaduct over the River Ness at Inverness.	All stone	5 arches of 73 feet, and 4 side arches of 20 feet span.	669	40	13,410	20 0 0	Single line.
13	Swing bridge over the Caledonian Canal.	Stone piers	2 wrought iron girders each 126 feet long, set on a turntable.	......	......	4,718	......	" "
14	Viaduct over the River Conon in Ross-shire.	All stone and at a skew of 45°	5 arches of 73 feet span built in square ribs.	540	45	11,391	21 2 0	" "

thick secured to piles. As it is situated close to Blair Castle, it has been made somewhat more ornate than was otherwise necessary. The cost of this bridge is £6500, being for a single line. Length 256 feet; cost £25 7*s*. 9*d*. per lineal foot; height above the bed of the river 40 feet.

No. 6 is a *bridge across the River Garry* at Calvine of 3 spans, one of 80 and two of 40 feet, and is 55 feet from the bed of the river to the top of the parapet. There was considerable difficulty in fixing the crossing of the river at this place. The Garry is here a large and rapid mountain-stream, on a rocky bed, with several falls immediately adjoining, running through an ornamental plantation, and as this was a spot of interest in the grounds of Blair Castle, we were precluded from crossing the river at any other point within the demesne. It occurred to the writer, however, as the road-bridge passed over about the narrowest part of the river, the object aimed at could be effected both economically and unobjectionably byspanning both road and river, thus forming an object of additional interest in this peculiar locality. The cost of this bridge was £5100. Length 274 feet; cost per lineal foot £18 12*s*. 3*d*.

No. 7 is a bridge of no particular interest, 80 feet span, crossing the *River Dulnain*, a mountain-stream near Grantown, but is given as a specimen of a substantial bridge of this size. The cost was:—Masonry £2238; iron work £1060. Total £3298. Length 148 feet; height 27 feet; cost per lineal foot £22 5*s*. 6*d*.

No. 8 is a viaduct crossing a picturesque ravine and stream called the *Divie*, 10 miles south of Forres. Its length is 477 feet, constructed for a single line, and the cost amounted to £10,231. It is 106 feet in height from the river-bed to the top of the parapet, and 16 feet in width; all the piers within the limits of the stream are founded on rock. It consists of seven arches of 45 feet span each. Cost per lineal foot £21 9*s*.

These viaducts constitute the principal works on the through line between Perth and Forres. The writer will now proceed to allude briefly to the principal works on the coast-line between Keith and Bonar Bridge.

The portion from Keith to Inverness being one-half the distance of the railway from Aberdeen to Inverness, the capital of the Highlands, extends to 55 miles in length. It may be stated that this portion from Inverness to Keith originally formed part of the Great North of Scotland Railway, the act for which was obtained in 1846, but pecuniary difficulties prevented the promoters from constructing this part of their scheme, involving, as it was then supposed, the construction of very heavy work in the neighbourhood of the River Spey, and it was eventually left to the Highland Companies to carry it out. There is a deep and precipitous ravine on the south side of the Spey, with flat meadows on the north side, and the original plan of the Great North of Scotland Company was to cross the river at a gradient of 1 in 90 with a high viaduct, with expensive works in the ravine, at a cost of about £100,000, the bridge being estimated at £60,000. After much careful survey and consideration, and consultation with Messrs. Locke and Errington regarding this work, it was fixed to pass through the ravine by a gradient of 1 in 60 for 2½ miles, which is the steepest gradient on the Highland system, and span the river by a box girder of 230 feet, with six side arches of masonry, each of 30 feet span, to meet the contingency of flood waters, which are on this river very sudden and very rapid, and the work has been carried out successfully. It may be mentioned that this was about the greatest single span of an open girder at the time built (1856). The propriety of a stone bridge at this place, with a gradient of 1 in 70, was considered by the Directors, but it was found to be too expensive. The present line, however, answers quite sufficiently for the traffic of the country,

which is now chiefly local since the opening of the Highland line. The cost of the bridge, which is 660 feet long and 74 feet high from the foundations to the top of the towers, constructed for a double line, was £34,480; cost per lineal foot £52 5*s*. The east abutment of this bridge is founded on rock, and it was provided that the west abutment should be sunk and founded on piles and a platform, the first imperfect trials having led to the conclusion that there was nothing beyond indurated shingle at this place. On sinking 14 feet from the surface, however, through a conglomerate of boulders 2 to 3 feet in diameter, hard mountain clay appeared, and on penetrating this for about 3 feet, rock was found, thus securing for this structure a rock foundation on either side. Immediately at the east end of this viaduct, the line, as already said, runs through a narrow and precipitous ravine, the stream of which had to be diverted for the railway, by a new channel cut out of the solid gravel 30 feet wide, sloping longitudinally 1 in 40, and pitched with stones from 12 to 18 inches deep. This pitching, which consists of squared stones, had to a small extent broken up several times since the line was opened ten years ago, from the floods bringing down stones and trees, and we found that the most effectual way of securing it was by inserting walings of timber 40 feet apart, 12 inches by 4 inches, across the channel, secured at every 3 feet by iron piles, and grouting the joints of the pitching in dry weather with lime-grout so as to prevent the lodgment of air and water, which under the pressure of floods has a tendency to dislocate the stone work.

No. 10 is a *viaduct crossing the Findhorn*, a dangerous and rapid river. It sometimes comes down in great flood, almost in a body of 2 or 3 feet of perpendicular height at a time, notwithstanding that in summer it is a very moderate-sized stream. This bridge consists of three spans of 150 feet each, with stone abutments and piers of solid ashlar, and is constructed for a single line. There was no appearance of rock in the immediate neighbourhood of the site, although rock appeared on one side of the river about half a mile above; and the channel, as far as could be ascertained, consisted of shingle and gravel. It was provided, therefore, that the foundation should be sunk 6 feet below the deepest part of the bed of the river on a platform and piles. The east abutment was so sunk, and the piles were driven through the gravel to a depth of 10 feet, making 16 feet below the bed of the river. It was observed that at that depth the piles uniformly would drive no further, and this suggested the possibility of rock. Rock was accordingly searched for, and it was found that about 18 feet under the bed of and across the river, rock existed. Cofferdams were therefore formed, and rock foundations were secured for the remaining piers and abutment. The cost of the bridge, including a pitched embankment on the east side, the bottom of which was secured by piles and a waling of timber, amounted—masonry to £11,170; ironwork £10,260, making a total of £21,430. Extreme length 608½ feet; height above foundations 46½ feet; cost per lineal foot £35 4*s*. 4*d*.

No. 11 *is a bridge across the River Nairn*, consisting of four arches of 55 feet span, and is an admirable piece of masonry. An incident connected with the foundations of this bridge deserves to be mentioned. The contractor, when instructed to ascertain the nature of the foundations, insisted that it was unnecessary to take any trouble about them, as rock cropped out on either bank; the turnpike-road bridge across the river a quarter of a mile below was founded on rock, and he said there could be no doubt that rock would be got in the centre 3 or 4 feet below the bed of the river. Rock, however, was not reached until we sunk from 13 to 14 feet, showing that experienced persons may be misled even under the most convincing circumstances. The structure, however, is founded on the solid rock throughout, and the cost for

a double line was £8620. Length 371 feet; height 56 feet; cost per lineal foot £23 4*s*. 8*d*.

No. 12 *is a viaduct across the Ness*, consisting of five arches of 73 feet span over the river, 4 land arches of 20 feet span, and 2 cast-iron openings of 27 and 35 feet span over roads. The foundations of this bridge, as in many others, consisted of shingle for 20 feet down, but at the north abutment and pier the iron rods driven in appeared to penetrate considerably easier than at other points of the channel, and it was deemed prudent to construct this abutment and pier upon bearing piles and a platform, and they were accordingly so done, as exhibited in the drawings. The total length of this bridge, including the side arches, is 669 feet, and the total height from the bed of the river to the top of the parapet is 40 feet. It is constructed for a single line, and cost £13,410. Cost per lineal foot £20.

No. 13 is a good example of a *swing bridge* built across the *Caledonian Canal*, which the line spans on a skew of 65 degrees. It consists of 2 girders of 126 feet in length, 78 feet of which, from the centre of the turn-table, spans the canal, and the remaining 48 feet forms the balance weight. Advantage was taken of the canal being emptied for repairs to lay the foundations of the masonry, which are on a platform and piles in the solid gravel, 9 feet below the surface of the water. The depth of the canal is 18 feet, and the width of the locks 40 feet, the canal banks being 120 feet apart. Some difficulty occurred at first during hot weather from the expansion of the iron affecting the adjustment and closing of the bridge, which was remedied by means of a powerful screw, and the bridge has been worked with satisfaction and safety for the last five years. This bridge, with its machinery, timber, wharves for protection from vessels, distant and station signals, &c., complete, cost £4718.

No. 14 *spans the River Conon in Ross-shire*. From peculiar circumstances it was necessary that this bridge should cross the river on a skew of 45 degrees to the stream, and as there were rock foundations, there was no difficulty to contend with beyond that of 4 or 5 feet of water in the channel of the river to reach the rock, which was successfully accomplished. The peculiarity of the skew with the river at this place would have been more easily provided for by the adoption of iron girders from pier to pier, but as the writer found at that time that iron girders would be fully as expensive, and not so permanent as a stone bridge, and as there were admirable quarries in the neighbourhood, he resolved to construct this bridge, as already said, on a skew of 45 degrees with the river, by a series of right-angled ribs or arches spanning from pier to pier. This is no new arrangement; but the writer is not aware of the plan being adopted for a series of arches of so large a span in any previous instance. The bridge consists of 5 arches of 73 feet span each, the arches being constructed of four ribs, each 3 feet 9 inches wide; the arch-stones are 4 feet deep at the springing, and 3 feet deep at the crown. The keystones of the centre part of each arch were made to connect with each other, as were the stones in the haunchings of the arches, and some cramps of iron were inserted at the joints to connect the ribs. The work was successfully accomplished, and constitutes a very perfect piece of bridge masonry. The total length of the bridge is 540 feet, and the height 45 feet from the bed of the river. The north abutment is founded 304 feet lower down the river than the south, and the whole structure, when the centres were removed, was found so accurately built that no joint in it showed any indication of setting. The cost of this bridge for a single line was £11,391. Cost per lineal foot £21 2*s*.

There are many other bridges, as may be supposed, over so great an extent

of country, and a country so much exposed to floods, but those above described are the principal; the entire waterway spanned over the entire system being 9828 feet.

On the Central Railway from Dunkeld to Forres, 104 miles, being a single line, there are 8 viaducts, 126 bridges over streams, 119 public and accommodation road-bridges, and 8100 yards of covered drains, varying in size from 18 to 36 inches square. There are 1650 lineal yards of breastwalls, 304,700 cubic yards of rock cutting, and 3,416,000 cubic yards of earthwork, being, including rock and earth, at the rate of 35,776 cubic yards to the mile. The largest embankment was at Rafford near Forres, which contained 308,000 cubic yards.

The permanent way consists of larch and natural-grown Scotch fir sleepers of the usual size, 3 feet apart; the chairs are 22 lbs. in weight; the rails weigh 75 lbs. to the lineal yard, are in lengths of 24 feet, and are fished at the joints.

The total cost of the works, including all extra and accommodation works, amounted for the 104 miles, to £798,311; the land, including severance, to £70,000; and the preliminary, parliamentary, engineering, and law expenses to £50,893, making the cost of this portion of the Company's lines £919,204, or £8860 per mile*.

The contracts were entered into immediately after the passing of the Bill in July 1861; the first turf of the railway was cut on the 17th of October of the same year, and the whole line was passed by the Government Inspector, and opened for public traffic on the 9th of September 1863, being one year and ten months, an unprecedentedly short time for works of such magnitude. The works between Forres and Dunkeld were divided into nine contracts let by public competition, and were undertaken £15,705 below the Engineer's estimate, and were completed at 12 per cent. over the Engineer's estimate, including 4 per cent. for accommodation works ordered by land valuators.

The traffic has been worked successfully and without accident for four years. The mail trains perform the journey between Inverness and Perth (144 miles) in $5\frac{1}{4}$ hours. It was proposed to the Post Office, but not agreed to, on account of the expense, to run them in four hours.

An ordinary goods train of 20 waggons, or 200 tons gross load, is drawn up the steepest inclines by one engine, having 17-inch cylinders and 24-inch stroke.

The traffic is rapidly increasing. The sheep and cattle, which used to reach the southern markets by a toilsome journey of a month or six weeks, are now conveniently transported in a day at less cost, the Company having carried in one week upwards of 21,000 sheep.

In passing over the mountain-ridges already described, it was feared that serious interruptions would arise from snow during the winter, but as the writer had a knowledge of the whole country for many years, he did not anticipate any difficulty on this head which might not be overcome. The summit is about 500 feet higher than that of the Caledonian line, or some 1500 feet in all above sea-level, and is no doubt more exposed. The first winter, viz. 1863–64, it was wholly open and the traffic uninterrupted; in February of the second winter, viz. 1865, a very heavy snow-storm occurred all over the north of Scotland, impeding the traffic of almost all the northern railways, and stopping the traffic on the Highland line for four or five days, which was only restored with great difficulty by the labour of large bodies of

* The extra work claimed by one Contractor is still unsettled, but is valued and paid at the rate at which the extra works on 160 miles of this system of railways have been amicably settled.

men. It was evident, therefore, that some decided steps must be adopted to overcome the snow difficulty, and in the beginning of 1866 the road was kept pretty well open by the application of snow-ploughs; and the experience of that winter made it quite clear that this difficulty might, with proper appliances, be effectually overcome, and means were accordingly adopted for that purpose.

In these elevated regions, when a snow-storm occurs, it is accompanied with high wind, and the snow is consequently drifted with great rapidity into the hollows and cuttings. With the view of obviating this, screen fences of light timber, or of decayed sleepers, or earthen mounds were erected a few yards from each side of the cuttings where the line was exposed. These were found very effective for intercepting the drifts. There was then provided snow ploughs of three descriptions, viz:—One, a light plough fixed to all the engines running on the line, and capable of clearing 12 to 24 inches of new snow. The second was a more formidable snow plough, which was fixed to a pilot engine, and was found capable of clearing 2 to 5 feet of snow. This pilot engine was attached to goods or passenger trains. The third, and largest class of plough was found to clear snow 10 or 11 feet deep, with the aid of four or five goods engines. These appliances, notwithstanding the very serious snow-storms which were encountered on the line in January last, were capable of keeping the line almost wholly clear.

This I consider a great triumph, inasmuch as the Highland line, over such high elevations, was kept clear, while, by the same storm, the lines throughout Scotland, England, and France were more or less blocked up; the lines in the north of Scotland being stopped entirely five or six days—the mails for Aberdeen being delayed three days from London, and two from Edinburgh. The Norfolk line was blocked up for some days; the Holyhead mail detained from 12 to 16 hours; the London, Chatham, and Dover blocked up for two days, as well as the trains in France to Marseilles.

Much credit is due to the activity and attention of the Highland Company's officers—Mr. Stroudley, the Locomotive Superintendent, and Mr. Buttle, Superintendent of Permanent Way—Mr. Stroudley having planned and constructed the snow-ploughs.

As a specimen of a cheaply constructed line of railway, the writer annexes a note of the details of the northern portion of the Highland Railway, from Invergordon to Bonar Bridge, $26\frac{1}{2}$ miles in length. The country through which this section of the line passes is comparatively level, and several parts skirt and run through the sea, where the works had to be protected at considerable cost. The cuttings amounted to 549,000 cubic yards, of which about 20,000 were rock. There are 27 bridges over streams, 4 of them 40 to 50 feet span, 26 public and accommodation road-bridges, and 2942 lineal yards of drains, varying from 18 to 36 inches square. The rails are double-headed and weigh 70 lbs. to the yard, and are fished at the joints; $\frac{5}{8}$ of the chairs are $20\frac{1}{2}$ lbs., and $\frac{3}{8}$ 28 lbs. in weight. There are ten stations, with permanent dwelling-houses for the agents and porters.

The total cost of this portion of the line, the works being of the very best quality, and the masonry all of stone, amounted to £5018 per mile, or including parliamentary and law expenses and land, £5888 per mile.

Commercially, these lines, extending over 246 miles, have not as yet been quite successful, from the fact of too great an extent of line having been undertaken at once, it requiring in an agricultural country considerable time to develope the traffic.

Under the whole circumstances, however, the traffic is satisfactory.

The works are of the most substantial character. The capital account,

which is under £2,800,000, is about closed as far as new works are concerned, while the revenue is rapidly increasing. For the half-year just ended, the Company will be able to pay its preference and debenture stocks, 5 per cent. on its floating liabilities, and about 2 per cent. on its ordinary stock of £740,000.

It will thus be seen that if the revenue increases in the same ratio that it has hitherto done, viz. from £15,000 to £20,000 per annum, the Company will be able to pay in two or three years a satisfactory dividend of 5 per cent. When that event occurs, the Directors may with propriety give some moderate aid to the further extension of the main lines of communication to Caithness and Skye, both of which must prove valuable feeders to the Highland system.

These lines were promoted chiefly by the great landed proprietors in the country, among the most prominent of which were the Earl of Seafield, Lord Fyfe, Mr. Matheson of Ardross, M.P., Mr. Merry of Belladrum, M.P., Mr. M'Intosh of Raigmore, Col. Fraser Tytler, the Duke of Sutherland, &c.

Experimental Researches on the Mechanical Properties of Steel.

By W. FAIRBAIRN, *LL.D., F.R.S., &c.*

THERE is probably no description of material that has undergone greater changes in its manufacture than iron; and, judging from the attempts that are now making, and have been made, to improve its quality and to enlarge its sphere of application, we may reasonably conclude that it is destined to attain still greater advances in its chemical and mechanical properties. The earliest improvements in the process of the manufacture of iron may be attributed to Cort, who introduced the process of boiling and puddling in the reverberatory furnace, and those of more recent date to Bessemer, who first used a separate vessel for the reduction of the metals, and thus effected more important changes in the manufacture of iron and steel than had been introduced at any former period in metallurgic history. To the latter system we owe most of the improvements that have taken place; for by the comparatively new and interesting process of burning out the carbon in a separate vessel almost every description of steel and refined iron may be produced. The same results may be obtained by the puddling furnace,—but not to the same extent, since the artificial blast of the Bessemer principle acts with much greater force in depriving the metal of its carbon, and in reducing it to the state of refined iron. By this new process increased facilities are afforded for attaining new combinations by the introduction of measured quantities of carbon into the converting vessel, and this may be so regulated as to form steel or iron of the homogeneous state, of any known quality.

By the boiling and puddling processes, steel of similar combinations may be produced, but with less certainty as regards quality, as everything depends on the skill of the operator in closing the furnace at the precise moment of time. This precaution is necessary in order to retain the exact quantity of carbon in the mass so as to produce by combination the requisite quality of steel. It will be observed that in the Bessemer process this uncertainty does not exist, as the whole of the carbon is volatilized or burnt out in the first instance; and by pouring into the vessel a certain quantity of crude metal containing carbon, any percentage of that element may be obtained in combination with the iron, possessing qualities best adapted to the varied forms of construction to which the metal may be applied. Thus the Bessemer system is not only more perfect in itself, but admits of a greater degree of certainty in the results than could possibly be attained from the

mere employment of the eyes and hands of the most experienced puddler. Thus it appears that the Bessemer process enables us to manufacture steel with any given proportion of carbon, or other eligible element, and thus to describe the compound metal in terms of its chemical constituents.

Important changes have been made since Mr. Bessemer first announced his new principle of conversion, and the results obtained from various quarters bid fair to establish a new epoch in metallurgic manipulation, by the production of a material of much greater general value than that which was produced by the old process, and in most cases of double the strength of iron.

These improvements are not exclusively confined to the Bessemer process, for a great variety of processes are now in operation producing the same results, and hence we have now in the market homogeneous, and every other description of iron, inclusive of steel of such density, ductility, &c., as to meet all the requirements of the varied forms of construction.

The chemical properties of these different kinds of steel have been satisfactorily established; but we have no reliable knowledge of the mechanical properties of the different kinds of homogeneous iron and steel that are now being produced. To supply this desideratum, I have endeavoured, by a series of laborious experiments, to determine the comparative values of the different kinds of steel, as regards their powers of resistance to transverse, tensile, and compressive strain.

These experiments have been instituted not only for those engaged in the constructive arts, but also to enable the engineer to make such selections of the material as will best suit his purpose in any proposed construction. In order to arrive at correct results, I have applied to the first houses for the specimens experimented upon, and judging from the results of these experiments, I venture to hope that new and important data have been obtained, which may safely be relied upon in the selection of the material for the different forms of construction.

For several years past attempts have been made to substitute steel for iron, on account of its superior tenacity and increased security in the construction of boilers, bridges, &c.; and assuredly there can be no doubt as to the desirability of employing a material of the same weight and of double the strength, provided it can at all times be relied upon. Some difficulties, however, exist, and until they are removed it would not be safe to make the transfer from iron to steel. These difficulties may be summed up in a few words, viz. the want of uniformity in the manufacture, in cases of rolled plates and other articles which require perfect resemblance in character, and the uncertainty which pervades its production. Time and close observation of facts in connexion with the different processes will, however, surmount these difficulties, and will enable the manufacturer to produce steel in all its varieties with the same certainty as he formerly attained in the manufacture of iron.

In the selection of the different specimens of steel, I have endeavoured to obtain such information about the ores, fuel, and process of manufacture as the parties supplying the specimens were disposed to furnish. To a series of questions, answers were, in most cases, cheerfully given, the particulars of which will be found in the Tables.

I have intimated that the specimens have been submitted to transverse, tensile, and compressive strain, and the summaries of results will indicate the uses to which the different specimens may be applied. Table I. gives for each specimen the modulus of elasticity and the modulus of resistance to impact, together with the deflection for unity of pressure; from these experi-

mental data the engineer and architect may select the steel possessing the actual quality required for any particular structure. This will be found especially requisite in the construction of boilers, ships, bridges, and other structures subjected to severe strains, where safety, strength, and economy should be kept in view.

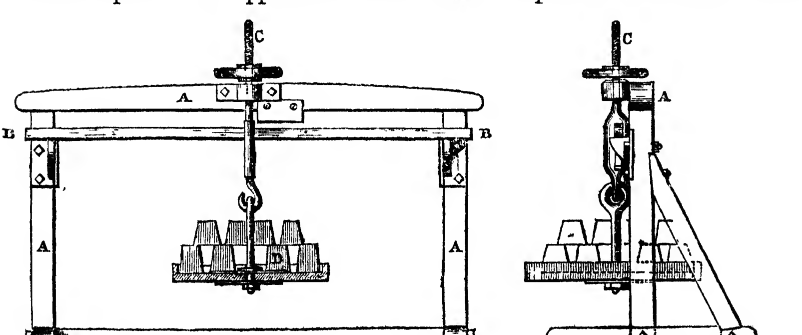
In the case of transverse strain some difficulties presented themselves in the course of the experiments, arising from the ductile nature of some part of the material, and from its tendency to bend or deflect to a considerable depth without fracture.

But this is always the case with tough bars whether of iron or steel, and hence the necessity of fixing upon some unit of measure of the deflections, in order to compare the flexibility of the bars with one another, and, from the mean value of this unit of deflection, to obtain a mean value of the modulus of elasticity (E) for the different bars. This unit or measure of flexibility given in the Table is the mean value of all the deflections corresponding to unity of pressure and section. The modulus of elasticity has also been calculated from the deflection produced by 112 lbs., in order that it may be compared with the results of experiments on cast iron, given at pages 73 and 74 in my work 'On the Application of Iron to Building Purposes.' In order to determine the resistance of the bars to a force analogous to that of impact, *the work* in deflecting each bar up to its limit of elasticity has been calculated. These results differ considerably from each other, showing the different degrees of hardness, ductility, &c. of the material of which the bars are composed. The transverse strength of the different bars up to their limit of elasticity is shown by the amount of the *modulus of strength* or *the unit of strength* calculated for each bar.

Table II., on tensile strain, gives the breaking strain of each bar per square inch of section, and the corresponding elongation of the bar per unit of length, together with the ultimate resistance of each bar to a force analogous to that of impact.

Table III., on compression, gives the force per square inch of section requisite to crush short columns of the different specimens, with the corresponding compression of the column per unit of length, together with the work expended in producing this compression.

Having selected the requisite number of specimens from different works, the experiments commenced with the transverse strains, which were conducted as on former occasions, by suspending dead weights from the middle of the bar, which was supported at its extremities, the supports being 4 feet 6 inches apart. The apparatus for this class of experiments consisted of the



wooden frame A, to which were bolted two iron brackets, BB, on which the bars were laid. Immediately over the centre of the bar, at a point equidistant between the supports, the wheel and screw C was attached to the scale D on which the weights were placed, 56 lbs. at a time; after each weight was laid on, the deflections were taken, and the experiment was continued until a large permanent set was obtained. The permanent set was observed at intervals in the following manner:—After the deflection produced by the load had been ascertained, the screw C was turned so as to raise the scale and relieve the bar of the load, thus enabling the experimenter to ascertain the effects of the load upon the bar and to register the permanent set. This operation was conducted with great precision, as may be seen on consulting the Tables in the experiments which follow.

Each of the bars have been treated in this way, care having been taken to secure portions of each bar for the experiments on tension and compression. In addition to these distinct tests, I have the advantage of my friend Mr. Tate's assistance in the reduction of formulæ as follows:—

FORMULÆ OF REDUCTION.

For the reduction of the Experiments on Transverse Strain.—When a bar is supported at the extremities and loaded in the middle,

$$E=\frac{wl^3}{4\delta K d^2}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where l is the distance between the supports, K the area of the section of the bar, d its depth, w the weight laid on added to $\frac{5}{8}$ths of the weight of the bar, δ the corresponding deflection, and E the modulus of elasticity.

When the section of a bar is a square,

$$E=\frac{wl^3}{4\delta d^4}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

These formulæ show that the deflection, taken within the elastic limit, for unity of pressure is a constant, that is, $\frac{\delta}{w}=D$, a constant.

Let $\frac{\delta_1}{w_1}, \frac{\delta_2}{w_2}, \ldots, \frac{\delta_n}{w_n}$ be a series of values of D, determined by experiment in a given bar, then

$$D=\frac{1}{n}\left(\frac{\delta_1}{w_1}+\frac{\delta_2}{w_2}+\ldots+\frac{\delta_n}{w_n}\right), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

which gives the mean value of this constant for a given bar.

Now, for the same material and length,

$$\frac{\delta}{w}, \text{ or } D \propto \frac{1}{Kd^2}; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and when the section of the bar is square,

$$\frac{\delta}{w}, \text{ or } D \propto \frac{1}{d^4}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

If D_1 be put for the value of D when $d=1$, then

$$\begin{aligned} D_1 &= Dd^4 \\ &= \frac{1}{n}\left(\frac{\delta_1}{w_1}+\frac{\delta_2}{w_2}+\ldots+\frac{\delta_n}{w_n}\right) d^4, \quad . \quad . \quad . \quad . \quad . \quad (6) \end{aligned}$$

which expresses the mean value of the deflection for unity of pressure and section. This mean value, therefore, may be taken as *the measure of the*

flexibility of the bar, or as the *modulus of flexure*, since it measures the amount of deflection produced by a unit of pressure for a unit of section.

Substituting this value in equation (2), we get

$$E=\frac{l^3}{4D_1}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

which gives the mean value of the modulus of elasticity, where D_1 is determined from equation (6).

The work U of deflection is expressed by the formula

$$U=\frac{1}{2}\times w\times\frac{\delta}{12}=\frac{w\delta}{24}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

where δ is the deflection in inches corresponding to the pressure (w) in lbs. If w and δ be taken at, or near to the elastic limit, then this formula gives the work, or resistance analogous to impact, which the bar may undergo, without suffering any injury in its material. This formula, reduced to unity of section, becomes

$$u=\frac{w\delta}{24K}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

If C be a constant, determined by experiment for the weight (W) straining the bar up to the limit of elasticity, so that the bar may be able to sustain the load without injury, then

$$\frac{Wl}{4}=CKd, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

where $C=\frac{1}{6}S$, or $\frac{1}{6}$ of the corresponding resistance of the material per square inch at the upper and lower edges of the section,

$$\therefore C=\frac{Wl}{4Kd}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

When the section of the bar is a square,

$$C=\frac{Wl}{4d^3}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

which gives the value of C, *the modulus of strength*, or the *unit of working strength*, W being the load, determined by experiment, which strains the bar up to its elastic limit: this value of C gives the comparative permanent or working strength of the bar.

Up to the elastic limit the deflections are proportional to their corresponding strains, but beyond this point the deflections increase in a much higher ratio. Hence the deflection corresponding to the elastic limit is the greatest deflection which is found to follow the elastic law just explained.

Tensile Strain, &c.—The work u expended in the elongation of a uniform bar, 1 foot in length and 1 inch in section, is expressed by

$$U=\frac{1}{2}\cdot\frac{P}{K}\cdot\frac{l}{L}=\frac{1}{2}P_1 l_1, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

where $P_1=\frac{P}{K}$=the strain in lbs. reduced to unity of section, and $l_1=\frac{l}{L}$ =the corresponding elongation reduced to unity of length.

This value of u, determined for the different bars subjected to experiment, gives a comparative measure of their powers of resistance to a strain analogous to that of impact.

By taking P_1 to represent the crushing pressure per unity of section, and l_1 the corresponding compression per unity of length, the foregoing formula will express the work expended in crushing the bar.

FIRST SERIES OF EXPERIMENTS.

TRANSVERSE STRAIN.

Experiment I.—Bar of Steel from Messrs. John Brown & Co., Sheffield. Dimension of bar ·97 inch square. Length between supports 4 feet 6 inches. Mark on bar, " B 1."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·088	....	Specimen of best cast steel from Russian and Swedish iron. Used for turning-tools.
2	100	·148		
3	150	·219		
4	200	·283	·004	
5	250	·353	·006	
6	300	·415	·008	
7	350	·433	·009	
8	400	·555		
9	450	·616	·011	
10	500	·690	·012	
11	550	·760		
12	600	·837		
13	650	·927		
14	700	·977		
15	750	1·047		
16	800	1·117	·012	
17	850	1·187	·015	
18	900	1·237		
19	950	1·307	·016	
20	1150	1·747	·101	
21	1400	....	....	Sunk with this weight.

Results of Exp. I.

Here the weight (w) corresponding to the limit of clasticity is 960 lbs., and the corresponding deflection (δ) is 1·307. See formulæ of reduction, p. 165.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0012048.

By formula (7).—The mean value of the modulus of elasticity (E) = 32,672,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 33,047,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 52·280.

By formula (9).—Work of deflection (u) for unity of section = 55·563.

By formula (12).—Value of C, the unit of working strength = 6·326 tons.

TRANSVERSE STRAIN.

Exp. II.—Bar of Steel from Messrs. John Brown & Co., Sheffield. Dimension of bar ·97 inch square. Length between supports 4 feet 6 inches. Mark on bar, "B 2."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·088	....	Specimen of best cast steel from Russian and Swedish iron, of milder quality than No. 1. Used for chisels &c.
2	100	·166		
3	150	·236		
4	200	·310		
5	250	·393		
6	300	·462		
7	350	·537		
8	400	·614		
9	450	·692		
10	500	·772		
11	550	·852		
12	600	·932		
13	650	1·012		
14	700	1·082	·001	
15	750	1·172		
16	800	1·242		
17	850	1·312	·001	
18	900	1·402	·005	
19	950	1·482	·012	
20	1150	2·642	·327	Gradually sinking with this weight.

Results of Exp. II.

Here the weight (w) corresponding to the limit of elasticity is 960 lbs., and the corresponding deflection (δ) 1·482.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0013377.

By formula (7).—The mean value of the modulus of elasticity (E) = 29,415,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 29,465,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 59·280.

By formula (9).—Work of deflection (u) for unity of section = 63·003.

By formula (12).—Value of C, the unit of working strength = 6·326 tons.

TRANSVERSE STRAIN.

Exp. III.—Bar of Steel from Messrs. John Brown & Co., Sheffield. Dimension of bar 1·001 inch square. Length between supports 4 feet 6 inches. Mark on bar, "B 3."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·072	....	Specimen of cast steel from Swedish iron. Employed in the construction of tools, &c.
2	100	·134		
3	150	·191		
4	200	·259		
5	250	·321		
6	300	·397		
7	350	·461		
8	400	·527		
9	450	·597		
10	500	·649		
11	550	·715		
12	600	·780		
13	650	·867		
14	700	·927		
15	750	·987		
16	800	1·057		
17	850	1·107		
18	900	1·167		
19	950	1·247	·000	
20	1150	1·507	·0166	
21	1400	1·887	·0420	Sinking with this weight.

Results of Exp. III.

Here the weight (w) at the limit of elasticity is 1160 lbs., and the corresponding deflection (δ) is 1·507.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0012891.

By formula (7).—The mean value of the modulus of elasticity (E) = 30,550,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 32,171,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 72·838.

By formula (9).—Work of deflection (u) for unity of section = 72·690.

By formula (12).—Value of C, the unit of working strength = 6·958 tons.

TRANSVERSE STRAIN.

Exp. IV.—Bar of Steel from Messrs. John Brown & Co., Sheffield. Dimension of bar ·98 inch square. Length between supports 4 feet 6 inches. Mark on bar, "B 4."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·082	....	Specimen of cast steel from Swedish iron, of milder quality than No. 3. Used for chisels.
2	100	·160		
3	150	·214		
4	200	·282		
5	250	·348		
6	300	·423	·000	
7	350	·494	·004	
8	400	·556	·007	
9	450	·618	·008	
10	500	·691		
11	550	·755	·009	
12	600	·820		
13	650	·908	·011	
14	700	·978	·012	
15	750	1·048	·008	
16	800	1·113		
17	850	1·178		
18	900	1·258		
19	950	1·318	·008	
20	1150	1·708	·095	
21	1400	....	....	Sunk with this weight.

Results of Exp. IV.

Here the weight (w) at the limit of elasticity is 960 lbs., and the corresponding deflection (δ) is 1·318.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0012581.

By formula (7).—The mean value of the modulus of elasticity (E) = 29,463,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 29,370,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 52·720.

By formula (9).—Work of deflection (u) for unity of section = 54·893.

By formula (12).—Value of C, the unit of working strength = 6·134 tons.

TRANSVERSE STRAIN.

EXP. V.—Bar of Steel from Messrs. John Brown & Co., Sheffield. Dimension of bar ·98 inch square. Length between supports 4 feet 6 inches. Mark on bar, "B 5."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·083	....	Specimen of steel cast from Swedish iron, of mild quality for welding.
2	100	·149		
3	150	·209		
4	200	·277		
5	250	·349		
6	300	·427		
7	350	·497		
8	400	·527		
9	450	·631		
10	500	·702		
11	550	·777	....	This specimen is considerably more ductile than any of the previous bars experimented upon. It is similar in character to that in Exp. II.
12	600	·845		
13	650	·927		
14	700	·997		
15	750	1·057	·000	
16	800	1·127	·003	
17	850	1·197		
18	900	1·267	·004	
19	950	1·337	·014	
20	1150	2·402	·664	The deflection continues to increase with this weight.

Results of Exp. V.

Here the weight (w) at the limit of elasticity is 960 lbs., and the corresponding deflection (δ) is 1·337.

By formula (6).—The mean value of the deflection for the unity of pressure and section (D_1) = ·0012673.

By formula (7).—The mean value of the modulus of elasticity (E) = 29,248,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 31,510,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 53·480.

By formula (9).—Work of deflection (u) for unity of section = 55·685.

By formula (12).—Value of C, the unit of working strength = 6·134 tons.

TRANSVERSE STRAIN.

Exp. VI.—Bar of Steel from Messrs. John Brown & Co., Sheffield. Dimension of bar ·992 inch square. Length between supports 4 feet 6 inches. Mark on bar, "B 6."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·076	. . .	Bar of Bessemer steel.
2	100	·138		
3	150	·208		
4	200	·280		
5	250	·346		
6	300	·414		
7	350	·486		
8	400	·554		
9	450	·624		
10	500	·694		
11	550	·757		
12	600	·824		
13	650	·894		
14	700	·964		
15	750	1·024		
16	800	1·094	·000	
17	850	1·174	·008	
18	900	1·284	·044	
19	950	1·434	·133	Experiment discontinued.

Results of Exp. VI.

Here the weight (w) at the limit of elasticity is 860 lbs., and the corresponding deflection (δ) is 1·174.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0013024.

By formula (7).—The mean value of the modulus of elasticity (E) = 30,224,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 32,361,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 42·068.

By formula (9).—Work of deflection (u) for unity of section = 42·749.

By formula (12).—Value of C, the unit of working strength = 5·297 tons.

TRANSVERSE STRAIN.

Exp. VII.—Bar of Steel from Messrs. John Brown & Co., Sheffield. Dimension of bar ·978 inch square. Length between supports 4 feet 6 inches. Mark on bar, "B 7."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·073	....	Specimen of double shear steel from Swedish bar.
2	100	·141		
3	150	·215		
4	200	·281		
5	250	·355		
6	300	·425		
7	350	·493		
8	400	·565		
9	450	·630		
10	500	·703		
11	550	·775		
12	600	·855		
13	650	·925		
14	700	1·015		
15	750	1·065	....	The experiments in this and the two next Tables were made for comparison with Exp. VI.
16	800	1·145	·000	
17	850	1·225	·005	
18	900	1·325	·031	
19	950	1·535	·142	

Results of Exp. VII.

Here the weight (w) at the limit of elasticity is 860 lbs., and the corresponding deflection (δ) is 1·225.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0012643.

By formula (7).—The mean value of the modulus of elasticity (E) = 31,135,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 33,523,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 43·900.

By formula (9).—Work of deflection (u) for unity of section = 45·897.

By formula (12).—Value of C, the unit of working strength = 5·527 tons.

TRANSVERSE STRAIN.

EXP. VIII.—Bar of Steel from Messrs. John Brown & Co., Sheffield. Dimension of bar ·986 inch square. Length between supports 4 feet 6 inches. Mark on bar, "B 8."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·069	....	Specimen of "Foreign Bar," not melted, but tilted direct from the ingot.
2	100	·143		
3	150	·204		
4	200	·273		
5	250	·340		
6	300	·418		
7	350	·485		
8	400	·550		
9	450	·623		
10	500	·700		
11	550	·777		
12	600	·850		
13	650	·930		
14	700	·990		
15	750	1·050		
16	800	1·130		
17	850	1·210	·000	
18	900	1·310	·017	
19	950	1·430	·059	

Results of Exp. VIII.

Here the weight (w) at the limit of elasticity is 860 lbs., and the corresponding deflection (δ) is 1·210.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0012863.

By formula (7).—The mean value of the modulus of elasticity (E) = 29,335,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 30,686,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 43·358.

By formula (9).—Work of deflection (u) for unity of section = 44·598.

By formula (12).—Value of C, the unit of working strength = 5·394 tons.

TRANSVERSE STRAIN.

EXP. IX.—Bar of Steel from Messrs. John Brown & Co., Sheffield. Dimension of bar 1 inch square. Length between supports 4 feet 6 inches. Mark on bar, "B 9."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·076	....	Specimen of (JB) bar. English tilted steel made from English and foreign pigs.
2	100	·136		
3	150	·206		
4	200	·270		
5	250	·318		
6	300	·380		
7	350	·450		
8	400	·516		
9	450	·570		
10	500	·640		
11	550	·700		
12	600	·780		
13	650	·840		
14	700	·900	....	It will be observed that the value of C, formula (12) of this experiment, is lower than those of Exp. VI., VII., and VIII.
15	750	·960		
16	800	1·020	·008	
17	850	1·100		
18	900	1·180	·024	
19	950	1·300	·083	

Results of Exp. IX.

Here the weight (w) at the limit of elasticity is 860 lbs., and the corresponding deflection (δ) is 1·100.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1)$=$·001258.

By formula (7).—The mean value of the modulus of elasticity (E) $=$ 31,292,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure $=$ 31,833,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity $=$ 39·416.

By formula (9).—Work of deflection (u) for unity of section $=$ 39·416.

By formula (12).—Value of C, the unit of working strength $=$ 5·170 tons.

Exp. X.—Bar of Steel from Messrs. Charles Cammell & Co., Sheffield. Dimension of bar 1·054 inch square. Length between supports 4 feet 6 inches. Mark on bar, "1."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·064	....	Specimen of cast steel, termed "Diamond Steel."
2	100	·117		
3	150	·172		
4	200	·225		
5	250	·273		
6	300	·333		
7	350	·382		
8	400	·427		
9	450	·476	·000	
10	500	·534	·006	
11	550	·585		
12	600	·632		
13	650	·687		
14	700	·741		
15	750	·801		
16	800	·860	....	This is a remarkably fine specimen of flexible steel; highly elastic.
17	850	·932		
18	900	·982	·006	
19	950	1·042	·011	
20	1000	1·092	·019	
21	1050	1·162		
22	1100	1·192		
23	1150	1·242		
24	1200	1·302	·022	
25	1250	1·362		
26	1300	1·372		
27	1350	1·452		
28	1400	1·512		
29	1450	1·562	·023	
30	1500	1·662	·028	
31	1550	1·742	·059	
32	1600	1·832	·065	
33	1654	1·922	·120	
34	1710	2·062	·189	
35	1766	2·302	·356	
36	1822	2·662	·546	
37	1878	3·042	·800	
38	1934	3 732	1·302	Sinking with this load.

Results of Exp. X.

Here the weight (w) at the limit of elasticity is 1460 lbs, and the corresponding deflection (δ) is 1·562.——By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0013081 ——By formula (7)—The mean value of the modulus of elasticity (E) = 30,088,000.——By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 29,996,000.——By formula (8)—Work of deflection (U) for unity of section = 95·000.——By formula (9).—Work of deflection (u) for unity of section = 85·515.——By formula (12).—Value of C, the unit of working strength = 7·504 tons.

Exp. XI.—Bar of Steel from Messrs. Charles Cammell & Co., Sheffield. Dimension of bar 1·104 inch square. Length between supports 4 feet 6 inches. Mark on bar, "2."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·064	....	Specimen of steel termed "Tool Steel."
2	100	·120		
3	150	·174		
4	200	·232		
5	250	·287		
6	300	·324		
7	350	·396		
8	400	·437		
9	450	·500		
10	500	·563		
11	550	·624		
12	600	·665		
13	650	·718		
14	700	·776		
15	750	·834		
16	800	·884		
17	850	·944		
18	860	·964	....	This appears to be a superior quality of steel, well adapted for the purpose for which it was manufactured.
19	890	·994		
20	920	1·024		
21	950	1·054		
22	990	1·094		
23	1010	1·134		
24	1040	1·164		
25	1070	1·194		
26	1100	1·224		
27	1130	1·254		
28	1160	1·284		
29	1200	1·314		
30	1230	1·374		
31	1260	1·404		
32	1300	1·414		
33	1350	1·524		
34	1400	1·614	·000	
35	1450	1·684	·010	
36	1500	1·784	·019	
37	1550	1·854	·059	
38	1600	1·864	·137	
39	1654	1·964	·306	

Results of Exp. XI.

Here the weight (w) at the limit of elasticity is 1460 lbs., and the corresponding deflection (δ) is 1·684.——By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·001637.——By formula (7).—The mean value of the modulus of elasticity (E) = 22,965,000.—— By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 24,288,000.——By formula (8).—Work of deflection (U) up to the limit of elasticity = 102·443.——By formula (9).—Work of deflection (u) for unity of section = 84·048.——By formula (12).—Value of C the unit of working strength = 5·904 tons.

TRANSVERSE STRAIN.

EXP. XII.—Bar of Steel from Messrs. Charles Cammell & Co., Sheffield. Dimension of bar ·994 inch square. Length between supports 4 feet 6 inches. Mark on bar, "3."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·076	....	Specimen of cast steel, termed "Chisel Steel."
2	100	·141		
3	150	·202		
4	200	·268		
5	250	·330		
6	300	·398		
7	350	·464		
8	400	·522		
9	450	·634		
10	500	·653		
11	550	·726		
12	600	·804		
13	650	·864		
14	700	·924	....	This is a description of steel similar to that in Exp. XI., but more ductile.
15	750	1·004		
16	800	1·064		
17	850	1·104		
18	900	1·194	·000	
19	950	1·244	·001	
20	1000	1·274		
21	1050	1·347	·002	
22	1100	1·454	·007	
23	1150	1·504	·014	
24	1200	1·594	·022	
25	1300	1·924	·165	
26	1380	2·484	·589	
27	1400	2·884	·898	
28	1430	3·114	1·076	
29	1450	3·294	1·285	

Results of Exp. XII.

Here the weight (w) at the limit of elasticity is 1210 lbs., and the corresponding deflection (δ) is 1·594.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0012612.

By formula (7).—The mean value of the modulus of elasticity (E) = 31,212,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure=31,474,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 77·864.

By formula (9).—Work of deflection (u) for unity of section = 78·825.

By formula (12).—Value of C, the unit of working strength = 7·413 tons.

TRANSVERSE STRAIN.

Exp. XIII.—Bar of Steel from Messrs. Charles Cammell & Co., Sheffield. Dimension of bar 1·04 inch square. Length between supports 4 feet 6 inches. Mark on bar, "4."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·068	....	Specimen of cast steel, termed "Double Shear Steel."
2	100	·125		
3	150	·179		
4	200	·239		
5	250	·298		
6	300	·346		
7	350	·389		
8	400	·456		
9	450	·508		
10	500	·568		
11	550	·626		
12	600	·693		
13	650	·740	·000	
14	700	·797	·001	
15	750	·850		
16	800	·936	·002	
17	850	·996	·003	
18	900	1·056		
19	950	1·106	·003	
20	1150	1·946	·106	
21	1400	3·536	1·695	Sunk with this weight.

Results of Exp. XIII.

Here the weight (w) at the limit of elasticity is 960 lbs., and the corresponding deflection (δ) is 1·106.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0013254.

By formula (7).—The mean value of the modulus of elasticity (E) = 29,700,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 30,126,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 44·240.

By formula (9).—Work of deflection (u) for unity of section = 40·903.

By formula (12).—Value of C, the unit of working strength = 5·132 tons.

TRANSVERSE STRAIN.

EXP. XIV.—Bar of Steel from Messrs. Charles Cammell & Co., Sheffield. Dimension of bar 1·02 inch square. Length between supports 4 feet 6 inches. Mark on bar, "5."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·060	....	Bar of hard Bessemer steel.
2	100	·120		
3	150	·169		
4	200	·228		
5	250	·288		
6	300	·350		
7	350	·425		
8	400	·487		
9	450	·550	....	This metal is of nearly the same quality as that in Exp. VI.
10	500	·604		
11	550	·664		
12	600	·733		
13	650	·780	·000	
14	700	·880	·004	
15	750	·940	·011	
16	800	1·000	·011	
17	850	1·060	·018	
18	900	1·140	·028	
19	950	1·270	·083	

Results of Exp. XIV.

Here the weight (w) at the limit of elasticity is 810 lbs., and the corresponding deflection (δ) is 1·000.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0012805.

By formula (7).—The mean value of the modulus of elasticity (E) = 30,742,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 33,205,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 33·750.

By formula (9).—Work of deflection (u) for unity of section = 32·439.

By formula (12).—Value of C, the unit of working strength = 4·588 tons.

TRANSVERSE STRAIN.

Exp. XV.—Bar of Steel from Messrs. Charles Cammell & Co., Sheffield. Dimension of bar ·992 inch square. Length between supports 4 feet 6 inches. Mark on bar, "6."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·077	....	Bar of soft Bessemer steel.
2	100	·142		
3	150	·208		
4	200	·280		
5	250	·343		
6	300	·427		
7	350	·481		
8	400	·544		
9	450	·615		
10	500	·673	·000	
11	550	·739	·001	This bar is much more ductile than those previously experimented upon.
12	600	·818		
13	650	·888		
14	770	1·052	·001	
15	800	1·098		
16	850	1·188	·094	
17	860	1·228		
18	890	1·248	·104	
19	900	1·318		
20	920	1·358	·160	
21	950	2·898	1·588	

Results of Exp. XV.

Here the weight (w) at the limit of elasticity is 810 lbs., and the corresponding deflection, (δ) is 1·098.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1)=·0012995.

By formula (7).—The mean value of the modulus of elasticity (E) pressure=30,291,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure=31,056,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity =37·057.

By formula (9).—Work of deflection (u) for unity of section=37·657.

By formula (12).—Value of C, the unit of working strength=4·988 tons.

TRANSVERSE STRAIN.

Exp. XVI.—Bar of Steel from Messrs. Naylor & Vickers, Sheffield. Dimension of bar 1 inch square. Length between supports 4 feet 6 inches. Mark on bar, "Axle Steel."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·072	....	Specimen of cast steel, converted in the crucible from bar-iron with the addition of manganese.
2	100	·140		
3	150	·200		
4	200	·261	·000	
5	250	·340		
6	300	·404		
7	350	·460		
8	400	·522		
9	450	·580		
10	500	·648	·010	
11	550	·700		
12	600	·780		
13	650	·840		From this experiment it would appear that manganese has a considerable effect in combination with the other constituents of steel.
14	700	·900		
15	750	·950		
16	800	1·020	·016	
17	850	1·090		
18	900	1·180	·018	
19	950	1·250	·046	
20	1000	1·370		
21	1050	1·620		
22	1100	3·380	1·915	Sunk with this weight.

Results of Exp. XVI.

Here the weight (w) at the limit of elasticity is 910 lbs., and the corresponding deflection (δ) is 1·180.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1)=·001273.

By formula (7).—The mean value of the modulus of elasticity (E) =30,923,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure=30,940,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity =44·741.

By formula (9).—Work of deflection (u) for unity of section=44·741.

By formula (12).—Value of C, the unit of working strength=5·472 tons.

TRANSVERSE STRAIN.

Exp. XVII.—Bar of Steel from Messrs. Naylor & Vickers, Sheffield. Dimension of bar ·998 inch square. Length between supports 4 feet 6 inches. Mark on bar, "Tyre Steel."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·087	....	Specimen of cast steel, converted in the crucible from bar-iron with the addition of manganese.
2	100	·157		
3	150	·219		
4	200	·287	·002	
5	250	·342		
6	300	·412		
7	350	·475		
8	400	·547		
9	450	·591		
10	500	·667	·015	
11	550	·732		
12	600	·797		
13	650	·857		
14	700	·927		
15	750	·987	·023	
16	800	1·057		
17	850	1·117		
18	900	1·197	·027	
19	950	1·287	·038	
20	1000	1·367	·074	
21	1050	1·537		
22	1100	2·697	1·192	

Results of Exp. XVII.

Here the weight (w) at the limit of elasticity is 910 lbs., and the corresponding deflection (δ) is 1·197.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0013124.

By formula (7).—The mean value of the modulus of elasticity (E) = 29,994,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 27,847,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 40·025.

By formula (9).—Work of deflection (u) for unity of section = 40·184.

By formula (12).—Value of C, the unit of working strength = 5·505 tons.

TRANSVERSE STRAIN.

EXP. XVIII.—Bar of Steel from Messrs. Naylor & Vickers, Sheffield. Dimension of bar 1·026 inch square. Length between supports 4 feet 6 inches. Mark on bar, "Vickers' Cast Steel, Special."

No, of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·133	....	Specimen of cast steel, converted in the crucible from bar-iron with the addition of manganese.
2	200	·253		
3	300	·363		
4	400	·485		
5	500	·599		
6	600	·711		
7	700	·828		
8	800	·983		
9	900	1·163	·000	
10	950	1·213	·000	The bar in this and the following experiment indicate a fine quality of metal, and great powers of resistance to a transverse strain.
11	1150	1·393		
12	1250	1·523		
13	1400	1·693	·016	
14	1500	1·183		
15	1600	1·973		
16	1712	2·133	·072	

Results of Exp. XVIII.

Here the weight (w) at the limit of elasticity is 1410 lbs., and the corresponding deflection (δ) is 1·693.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1)=·0013386.

By formula (7).—The mean value of the modulus of elasticity (E) =29,407,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure=29,385,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity =99·463.

By formula (9).—Work of deflection (u) for unity of section=94·485.

By formula (12).—Value of C, the unit of working strength=7·856 tons.

TRANSVERSE STRAIN.

EXP. XIX.—Bar of Steel from Messrs. Naylor & Vickers, Sheffield. Dimensions of bar 1·01 inch square. Length between supports 4 feet 6 inches. Mark on bar, "Naylor & Vickers' Cast Steel, 2·66."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·076	....	Specimen of cast steel, converted in the crucible from bar-iron with the addition of manganese.
2	100	·140		
3	150	·195		
4	200	·257	·000	
5	250	·313		
6	300	·372		
7	350	·440		
8	400	·500		
9	450	·560		
10	500	·620	·008	
11	550	·678		
12	600	·737		
13	650	·800		
14	700	·870		
15	750	·940		
16	800	1·000	·010	
17	850	1·050		
18	900	1·120	·014	This bar is similar to the foregoing, but less rigid.
19	950	1·190	·017	
20	1000	1·250		
21	1050	1·310		
22	1100	1·370		
23	1150	1·440		
24	1200	1·500		
25	1250	1·570	·017	
26	1400	1·850		
27	1500	2·310	·353	
28	1585	2·650		
29	1637	3·350	1·020	

Results of Exp. XIX.

Here the weight (w) at the limit of elasticity is 1260 lbs., and the corresponding deflection (δ) is 1·570.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1)=·0012789.

By formula (7).—The mean value of the modulus of elasticity (E) =30,788,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure=29,752,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity =82·412.

By formula (9).—Work of deflection (u) for unity of section=80·788.

By formula (12).—Value of C, the unit of working strength=7·358 tons.

TRANSVERSE STRAIN.

Exp. XX.—Bar of Steel from Mr. S. Osborn, Clyde Works, Sheffield. Dimension of bar 1·038 inch square. Length between supports 4 feet 6 inches. Mark on bar, "1. Best Tool Cast Steel, ."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·140	....	Specimen of turning-tool cast steel.
2	200	·252	·010	
3	300	·364		
4	350	·424		
5	400	·482	·017	
6	450	·540		
7	500	·600	·020	
8	550	·666		
9	600	·727		
10	650	·787		
11	700	·844		
12	750	·904		
13	800	·964	·034	
14	850	1·044		
15	900	1·094		
16	950	1·144	·035	
17	1000	1·204		
18	1050	1·274		
19	1100	1·324	·059	
20	1200	1·474	·076	
21	1300	1·684		
22	1350	2·044	·343	
23	1400	2·344		
24	1450	2·654		
25	1500	3·034	1·001	Sinking under this load.

Results of Exp. XX.

Here the weight (w) at the limit of elasticity is 1010 lbs., and the corresponding deflection (δ) is 1·204.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1)=·0013886.

By formula (7).—The mean value of the modulus of elasticity (E) =28,353,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure=26,689,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity =50·668.

By formula (9).—Work of deflection (u) for unity of section=48·813.

By formula (12).—Value of C, the unit of working strength=5·432 tons.

TRANSVERSE STRAIN.

Exp. XXI.—Bar of Steel from Mr. S. Osborn, Clyde Works, Sheffield. Dimension of bar 1·01 × 1·014 inch. Length between supports 4 feet 6 inches. Mark on bar, "2. Best Chisel Cast Steel."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·136	....	Specimen of best cast steel for cold-chipping chisels.
2	200	·260	·002	
3	300	·382		
4	400	·508		
5	500	·628	·009	
6	600	·712		
7	700	·836		
8	800	·978	·010	
9	850	1·068		
10	900	1·138	·008	
11	950	1·198	·013	
12	1000	1·248		
13	1050	1·318	....	This bar is close ground and well adapted for tools.
14	1100	1·388	·029	
15	1150	1·448		
16	1200	1·538		
17	1250	1·648		
18	1300	1·808		
19	1350	2·028		
20	1400	2·328	·471	
21	1450	2·588		
22	1500	3·058	·970	Sunk under this weight.

Results of Exp. XXI.

Here the weight (w) at the limit of elasticity is 1110 lbs., and the corresponding deflection (δ) is 1·388.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1)=·001278.

By formula (7).—The mean value of the modulus of elasticity (E) =30,802,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure=30,523,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity =64·195.

By formula (9).—Work of deflection (u) for unity of section = 62·684.

By formula (12).—Value of C, the unit of working strength = 6·400 tons.

TRANSVERSE STRAIN.

Exp. XXII.—Bar of Steel from Mr. S. Osborn, Clyde Works, Sheffield. Dimension of bar 1·09 inch square. Length between supports 4 feet 6 inches. Mark on bar, "3. Silver Steel, ."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·139		Specimen of best cast steel for hot and cold sates-cups, shear-blades, and boiler-makers' steel.
2	200	·266	·007	
3	300	·387		
4	350	·458		
5	400	·520	·014	
6	450	·576		
7	500	·636	·014	
8	550	·701		
9	600	·760		
10	650	·840		
11	700	·910	·014	
12	750	·950		
13	800	1·010	·019	
14	850	1·090		
15	900	1·150		
16	950	1·230	·019	
17	1000	1·290		
18	1050	1·370		
19	1100	1·500	·075	
20	1150	1·660		
21	1200	1·910	·314	
22	1250	2·210		
23	1300	2·760	·931	Yielded with this weight.

Results of Exp. XXII.

Here the weight (w) at the limit of elasticity is 1010 lbs., and the corresponding deflection (δ) is 1·290.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0017814.

By formula (7).—The mean value of the modulus of elasticity (E) = 22,098,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 22,072,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 54·287.

By formula (9).—Work of deflection (u) for unity of section = 47·845.

By formula (12).—Value of C, the unit of working strength = 4·691 tons.

TRANSVERSE STRAIN.

Exp. XXIII.—Bar of Steel from Mr. S. Osborn, Clyde Works, Sheffield. Dimension of bar ·994 × 1·006 inch. Length between supports 4 feet 6 inches. Mark on bar, "4. Improved Die Steel, ."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·144		Specimen of best cast steel
2	200	·284	·010	for taps and dies.
3	300	·408		
4	350	·472		
5	400	·538	·011	
6	450	·600		
7	500	·672		
8	550	·748		
9	600	·804		
10	650	·894		
11	700	·954	·012	
12	800	1·074	·016	Specimen of steel similar to
13	850	1·154		the last.
14	900	1·214	·018	
15	950	1·264	·025	
16	1000	1·344		
17	1050	1·434		
18	1100	1·544	·091	
19	1150	1·694		
20	1200	1·934		
21	1250	2·474	·688	Sunk with this weight.

Results of Exp. XXIII.

Here the weight (w) at the limit of elasticity is 1010 lbs., and the corresponding deflection (δ) is 1·344.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0013409.

By formula (7).—The mean value of the modulus of elasticity (E) = 29,368,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 29,718,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 56·433.

By formula (9).—Work of deflection (u) for unity of section = 56·435.

By formula (12).—Value of C, the unit of working strength = 6·037 tons.

TRANSVERSE STRAIN.

Exp. XXIV.—Bar of Steel from Mr. S. Osborn, Clyde Works, Sheffield. Dimension of bar 1·03 inch square. Length between supports 4 feet 6 inches. Mark on bar, "5. Toughened Cast Steel for Shafts, &c."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·072		Specimen of toughened cast steel for shafts, piston-rods, and machinery purposes.
2	100	·130		
3	150	·185		
4	200	·238	·010	
5	250	·298		
6	300	·358		
7	350	·414		
8	400	·474		
9	450	·532		
10	500	·586	·014	
11	550	·642		
12	600	·700		An average quality, suitable for general purposes.
13	650	·764		
14	700	·818		
15	750	·900		
16	800	·940		
17	850	1·030		
18	900	1·080	·009?	
19	950	1·140	·009?	
20	1000	1·190		
21	1050	1·270		
22	1100	1·330		
23	1150	1·420		
24	1200	1·560	·152	
25	1300	2·880	1·259	

Results of Exp. XXIV.

Here the weight (w) at the limit of elasticity is 1010 lbs., and the corresponding deflection (δ) is 1·190.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0013112.

By formula (7).—The mean value of the modulus of elasticity (E) = 26,398,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 29,610,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 50·079.

By formula (9).—Work of deflection (u) for unity of section = 53·194.

By formula (12).—Value of C, the unit of working strength = 5·559 tons.

TRANSVERSE STRAIN.

Exp. XXV.—Bar of Steel from Mr. S. Osborn, Clyde Works, Sheffield. Dimension of bar 1·04 inch square in centre. Length between supports 4 feet 6 inches. Mark on bar, "6. Double Shear Steel, ."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	300	·346	·007	Specimen of best double shear steel.
2	500	·572	·020?	
3	550	·625		
4	600	·682	·018	
5	650	·737		
6	700	·802		
7	750	·872		
8	800	·942	·030	
9	850	1·012		
10	900	1·072	·051	
11	950	1·152	·074	
12	1000	1·272		
13	1050	1·432		
14	1100	1·562	·321	
15	1150	1·892	·547	
16	1200	2·362	·920	

Results of Exp. XXV.

Here the weight (w) at the limit of elasticity is 860 lbs, and the corresponding deflection (δ) is 1·012.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0016881.

By formula (7).—The mean value of the modulus of elasticity (E) = 23,319,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 23,948,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 31·792.

By formula (9).—Work of deflection (u) for unity of section = 29·393.

By formula (12).—Value of C, the unit of working strength = 4·329 tons.

TRANSVERSE STRAIN.

Exp. XXVI.—Bar of Steel from Mr. S. Osborn, Clyde Works, Sheffield. Dimension of bar 1·02 inch in middle. Length between supports 4 feet 6 inches. Mark on bar, "7. Extra Best Tool Cast Steel, ."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·143	....	Specimen of extra best cast
2	200	·265	·007	steel for turning-tools,
3	300	·388		wheel-axles, &c.
4	400	·503	·010	
5	450	·576		
6	500	·627		
7	550	·683		
8	600	·748		
9	650	·823		
10	700	·883		
11	750	·943	....	This is a superior quality,
12	800	1·013		well adapted for axles.
13	850	1·083		
14	900	1·143	·009	
15	950	1·203	·009	
16	1000	1·263		
17	1050	1·313		
18	1100	1·363	·029	
19	1150	1·443		
20	1200	1·503	·025	
21	1250	1·553		
22	1300	1·643		
23	1350	1·743		
24	1400	1·803	·055	
25	1450	1·913		
26	1500	2·103		
27	1550	2·323		
28	1600	2·653		
29	1650	3·153	·824	Sunk with this weight.

Results of Exp. XXVI.

Here the weight (w) at the limit of elasticity is 1210 lbs., and the corresponding deflection (δ) is 1·503.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·001348.

By formula (7).—The mean value of the modulus of elasticity (E) = 29,188,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 28,013,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 75·776.

By formula (9).—Work of deflection (u) for unity of section = 72·826.

By formula (12).—Value of C, the unit of working strength = 6·860 tons.

TRANSVERSE STRAIN.

EXP. XXVII.—Bar of Steel from Mr. S. Osborn, Clyde Works, Sheffield. Dimension of bar 1·006 inch square in centre. Length between supports 4 feet 6 inches. Mark on bar, "8. Cast Steel for Boiler Plates, ."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·143	....	Specimen of cast steel for boiler plates.
2	200	·266	·012 ?	
3	300	·390		
4	400	·500		
5	500	·630		
6	550	·693		
7	600	·751	·010	
8	650	·823		
9	700	·900		
10	750	·960	....	It is assumed that this bar has been taken from the ingot intended for boiler plates.
11	800	1·020	·016	
12	850	1·120		
13	900	1·180	·013 ?	
14	950	1·250	·021	
15	1000	1·320		
16	1050	1·390		
17	1100	1·450	·063	
18	1150	1·550		
19	1200	2·000	·430	
20	1250	2·240		
21	1300	3·160	1·399	Disabled with this weight.

Results of Exp. XXVII.

Here the weight (w) at the limit of elasticity is 1010 lbs., and the corresponding deflection (δ) is 1·320.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0013007.

By formula (7).—The mean value of the modulus of elasticity (E) = 30,335,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 29,585,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 50·000.

By formula (9).—Work of deflection (u) for unity of section = 49·406.

By formula (12).—Value of C, the unit of working strength = 5·671 tons.

TRANSVERSE STRAIN.

Exp. XXVIII.—Bar of Steel from Messrs. Bessemer & Co., Sheffield. Dimension of bar ·99 inch square. Length between supports 4 feet 6 inches. Mark on bar, "B S 1."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·155	....	Specimen of hard Bessemer steel.
2	200	·294	·010	
3	300	·434		
4	400	·570		
5	500	·710	·012	
6	600	·840		
7	700	·980	·010	
8	750	1·050		
9	800	1·090		
10	850	1·170	....	This is a valuable quality of metal.
11	900	1·250		
12	950	1·320	·010	
13	1000	1·390		
14	1050	1·450		
15	1100	1·530	·023	
16	1200	1·690	·060	
17	1300	1·990	·165	
18	1350	2·180		
19	1400	2·520	·519	
20	1450	3·660	1·450	Disabled with this weight.

Results of Exp. XXVIII.

Here the weight (w) at the limit of elasticity is 1110 lbs., and the corresponding deflection (δ) is 1·530.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0021814.

By formula (7).—The mean value of the modulus of elasticity (E) = 29,652,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 29,104,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 70·762.

By formula (9).—Work of deflection (u) for unity of section = 72·199.

By formula (12).—Value of C, the unit of working strength = 6·882 tons.

TRANSVERSE STRAIN.

EXP. XXIX.—Bar of Steel from Messrs. Bessemer & Co., Sheffield. Dimension of bar 1 × 1·02 inch. Length between supports 4 feet 6 inches. Mark on bar, "B S 2."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·144	....	Specimen of milder Bessemer steel than No. 1.
2	200	·274	·021	
3	300	·305		
4	400	·466	·029	
5	500	·590	·030	
6	600	·716		
7	700	·850	·030	
8	750	·910		
9	800	·970	·030	
10	850	1·020		
11	900	1·110	·034	
12	950	1·270	·047	
13	1000	1·340		
14	1050	1·540		
15	1100	2·98	1·565	

Results of Exp. XXIX.

Here the weight (w) at the limit of elasticity is 910 lbs., and the corresponding deflection (δ) is 1·110.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0012946.

By formula (7).—The mean value of the modulus of elasticity (E) = 30,478,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 28,379,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 42·087.

By formula (9).—Work of deflection (u) for unity of section = 41·261.

By formula (12).—Value of C, the unit of working strength = 5·317 tons.

TRANSVERSE STRAIN.

Exp. XXX.—Bar of Steel from Messrs. Bessemer & Co., Sheffield. Dimension of bar ·957 × ·966 inch. Length between supports 4 feet 6 inches. Mark on bar, "B S 3."

No of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·176	....	Specimen of soft Bessemer steel.
2	200	·328	·006	
3	300	·479		
4	400	·628	·009	
5	450	·704		
6	500	·788	·014	
7	600	·944		
8	650	1·034		
9	700	1·094	·026	
10	750	1·204		
11	800	1·454	·237	This bar is much inferior to the two preceding ones.

Results of Exp. XXX.

Here the weight (w) at the limit of elasticity is 710 lbs., and the corresponding deflection (δ) is 1·094.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1)=·0015293.

By formula (7).—The mean value of the modulus of elasticity (E) =29,310,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure=28,536,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity =32·364.

By formula (9).—Work of deflection (u) for unity of section=35·008.

By formula (12).—Value of C, the unit of working strength=4·778 tons.

TRANSVERSE STRAIN.

Exp. XXXI.—Bar of Steel from Messrs. Sanderson Brothers, Sheffield. Dimension of bar 1·048 inch square. Length between supports 4 feet 6 inches. Mark on bar, "S 1."

No of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·114	....	Specimen of bar of cast steel, from K. B., a Russian iron, suitable for welding.
2	200	·216	·002	
3	300	·322		
4	400	·424		
5	500	·530	·002	
6	600	·640		
7	700	·740	·002	
8	800	·856	·002	
9	900	·990	·004	
10	950	1·050	·006	
11	1000	1·130		
12	1050	1·180		
13	1100	1·240	·057	
14	1150	1·340		
15	1200	1·440		
16	1250	1·500		
17	1300	1·590	·409	
18	1350	2·100		
19	1400	2·790		
20	1450	3·480	1·720	

Results of Exp. XXXI.

Here the weight (w) at the limit of elasticity is 1060 lbs., and the corresponding deflection (δ) is 1·180.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1)=·0012822.

By formula (7).—The mean value of the modulus of elasticity (E) =30,700,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure=31,482,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity =52·116.

By formula (9).—Work of deflection (u) for unity of section=47·452.

By formula (12).—Value of C, the unit of working strength=5·539 tons.

TRANSVERSE STRAIN.

Exp. XXXII.—Bar of Steel from Messrs. Sanderson Brothers, Sheffield. Dimension of bar 1·044 inch square. Length between supports 4 feet 6 inches. Mark on bar, "S 2."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·130		Specimen of double shear steel, from ℒ Swedish iron.
2	200	·238	·010	
3	300	·342		
4	400	·448		
5	500	·568	·010	
6	600	·682		
7	700	·794		
8	800	·920	·010	
9	900	1·040	·018	
10	950	1·110	·054	
11	1000	1·190	·075	
12	1100	1·680	·427	
13	1200	2·110		
14	1250	2·470		
15	1300	2·740	·954	
16	1350	3·130	1·450	

Results of Exp. XXXII.

Here the weight (w) at the limit of elasticity is 910 lbs., and the corresponding deflection (δ) is 1·040.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0013412.

By formula (7).—The mean value of the modulus of elasticity (E) =29,351,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure=28,074,000.

By formula (8).—The work of deflection (U) up to the limit of elasticity =39·433.

By formula (9).—Work of deflection (u) for unity of section=37·022.

By formula (12).—Value of C, the unit of working strength=4·808 tons.

TRANSVERSE STRAIN.

Exp. XXXIII.—Bar of Steel from Messrs. Sanderson Brothers, Sheffield. Dimension of bar 1·024 inch square. Length between supports 4 feet 6 inches. Mark on bar, "S 3."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·132	....	Specimen of single shear steel from Z a Swedish iron.
2	200	·250	·004	
3	300	·364		
4	400	·478		
5	500	·596	·004	
6	600	·716		
7	700	·832	·004	
8	800	·956	·004	
9	900	1·076	·004	
10	950	1·136	·007	A fine flexible metal, not subject to fracture.
11	1000	1·186		
12	1050	1·256		
13	1100	1·306	·021	
14	1200	1·416		
15	1300	1·586	·045	
16	1500	2·546	·647	
17	1600	3·576	1·883	

Results of Exp. XXXIII.

Here the weight (w) at the limit of elasticity is 1210 lbs., and the corresponding deflection (δ) is 1·416.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0012963.

By formula (7).—The mean value of the modulus of elasticity (E) =30,368,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure=29,858,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity =71·390.

By formula (9).—Work of deflection (u) for unity of section=68·082.

By formula (12).—Value of C, the unit of working strength=6·780 tons.

TRANSVERSE STRAIN.

Exp. XXXIV.—Bar of Steel from Messrs. Sanderson Brothers, Sheffield. Dimension of bar 1·046 inch square. Length between supports 4 feet 6 inches. Mark on bar, "S 4."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·124	....	Bar of faggot-steel drawn from $\mathcal{G}_L$ bar-steel, simply welded to make it sound.
2	200	·235	·008	
3	300	·341		
4	400	·446		
5	500	·550	·008	
6	600	·657		
7	700	·768		
8	800	·890	·008	
9	900	1·000		
10	950	1·050	·011	
11	1000	1·120		
12	1050	1·170		
13	1100	1·240	·045	
14	1150	1·320		
15	1200	1·460		
16	1300	2·300	·763	
17	1400	3·190	1·479	Sinking with this load.

Results of Exp. XXXIV.

Here the weight (w) at the limit of elasticity is 1060 lbs., and the corresponding deflection (δ) is 1·170.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0013616.

By formula (7).—The mean value of the modulus of elasticity (E) = 29,922,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 29,184,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 51·675.

By formula (9).—Work of deflection (u) for unity of section = 47·230.

By formula (12).—Value of C, the unit of working strength = 5·572 tons.

TRANSVERSE STRAIN.

Exp. XXXV.—Bar of Steel from Messrs. Sanderson Brothers, Sheffield. Dimension of bar 1·037 inch square. Length between supports 4 feet 6 inches. Mark on bar, "S'5 extra ."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·133	....	Specimen of drawn bar from GL steel, not welded.
2	200	·245	·011	
3	300	·359		
4	400	·459		
5	500	·573	·015	
6	600	·691		
7	700	·807		
8	800	·927	·016	
9	900	1·057	·019	
10	950	1·137	·034	
11	1000	1·217		
12	1100	1·737	·420	
13	1200	2·757	1·237	

Results of Exp. XXXV.

Here the weight (w) at the limit of elasticity is 910 lbs., and the corresponding deflection (δ) is 1·057.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0013333.

By formula (7).—The mean value of the modulus of elasticity (E) = 29,524,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 28,179,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 40·078.

By formula (9).—Work of deflection (u) for unity of section = 37·269.

By formula (12).—Value of C, the unit of working strength = 4·907 tons.

TRANSVERSE STRAIN.

Exp. XXXVI.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Dimension of bar 1·023 inch square. Length between supports 4 feet 6 inches. Mark on bar, "A."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·128	....	Specimen of steel employed in the manufacture of cups.
2	200	·246	·007	
3	250	·300		
4	300	·360		
5	400	·476	·007	
6	500	·596	·006	
7	600	·714		
8	700	·850	·004	
9	800	·970	·005	
10	900	1·090	·009	
11	950	1·160	·013	
12	1000	1·230		
13	1050	1·370		
14	1100	1·910	·574	
15	1150	2·660	1·187	This steel is very soft.

Results of Exp. XXXVI.

Here the weight (w) at the limit of elasticity is 960 lbs., and the corresponding deflection (δ) is 1·160.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0013033.

By formula (7).—The mean value of the modulus of elasticity (E) = 30,204,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 30,895,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 46·400.

By formula (9).—Work of deflection (u) for unity of section = 45·369.

By formula (12).—Value of C, the unit of working strength = 5·392 tons.

TRANSVERSE STRAIN.

Exp. XXXVII.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Dimension of bar 1·032 inch square. Length between supports 4 feet 6 inches. Mark on bar, "B."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·122	....	Specimen of steel used in the manufacture of drills.
2	200	·233	·002	
3	300	·358		
4	400	·460	·003	
5	500	·580		
6	600	·690		
7	700	·830	·004	
8	800	·930		
9	950	1·100	·004	
10	1050	1·220	·011	Useful tool steel.
11	1100	1·280		
12	1150	1·340	·014	
13	1200	1·410		
14	1250	1·480	·030	
15	1300	1·540		
16	1350	1·630	·037	
17	1400	1·700		
18	1450	1·870		
19	1500	2·140		
20	1600	2·810	·748	Disabled.

Results of Exp. XXXVII.

Here the weight (w) at the limit of elasticity is 1210 lbs., and the corresponding deflection (δ) is 1·410.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0012958.

By formula (7).—The mean value of the modulus of elasticity (E) = 30,390,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 31,297,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 71·087.

By formula (9).—Work of deflection (u) for unity of section = 66·748.

By formula (12).—Value of C, the unit of working strength = 6·625 tons.

TRANSVERSE STRAIN.

Exp. XXXVIII.—Bar of Steel from Messrs. Turton and Sons, Sheffield. Dimension of bar ·998 inch square. Length between supports 4 feet 6 inches. Mark on bar, "C."

No of Exp	Weight laid on, in lbs	Deflection, in inches	Permanent set, in inches	Remarks.
1	100	·137	. . .	Specimen of steel used in the manufacture of cutters.
2	200	·259		
3	300	·395		
4	400	·527	·024	
5	500	·615		
6	600	·770		
7	700	·915	·025	
8	800	1·035		
9	950	1·225	·025	The same in quality as that in the previous experiment.
10	1050	1·335		
11	1100	1·415	·031	
12	1150	1·495	·034	
13	1200	1·575		
14	1250	1·685	·077	
15	1300	1·805		
16	1350	2·305		
17	1400	2·935	·968	Sunk.

Results of Exp. XXXVIII.

Here the weight (w) at the limit of elasticity is 1100 lbs., and the corresponding deflection (δ) is 1·415.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·0012598.

By formula (7).—The mean value of the modulus of elasticity (E) = 31,247,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 31,859,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 65·443.

By formula (9).—Work of deflection (u) for unity of section = 65·705.

By formula (12).—Value of C, the unit of working strength = 6·718 tons.

TRANSVERSE STRAIN.

Exp. XXXIX.—Bar of Steel from Messrs. Turton and Sons, Sheffield. Dimension of bar ·986 inch square. Length between supports 4 feet 6 inches. Mark on bar, "D."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·141	....	Specimen of steel used in the construction of turning tools.
2	200	·278		
3	300	·417		
4	400	·558		
5	500	·693		
6	600	·828		
7	700	·978	·001	The same quality as before.
8	800	1·078	·002	
9	950	1·348	·009	
10	1000	1·408		
11	1050	1·488		
12	1100	1·578	·055	
13	1150	1·828	·185	
14	1200	2·078		
15	1250	2·538	·619	

Results of Exp. XXXIX.

Here the weight (w) at the limit of elasticity is 1010 lbs., and the corresponding deflection (δ) is 1·408.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·001287.

By formula (7).—The mean value of the modulus of elasticity (E) = 30,887,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 32,462,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 59·253.

By formula (9).—Work of deflection (u) for unity of section = 60·949.

By formula (12).—Value of C, the unit of working strength = 6·337 tons.

TRANSVERSE STRAIN.

Exp. XL.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Dimension of bar 1·02 inch square. Length between supports 4 feet 6 inches. Mark on bar, "E."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·130	....	Specimen of steel used in the manufacture of machinery.
2	200	·254		
3	300	·373		
4	400	·484	·004	
5	500	·593	·006	
6	600	·718		
7	700	·842		
8	800	·982	·007	
9	950	1·172	·011	The whole of these specimens (XXXVI., XXXVII., XXXVIII., XXXIX., and XL.) are remarkable for uniformity in strength and texture.
10	1050	1·262		
11	1100	1·342	·014	
12	1150	1·402	·015	
13	1200	1·472		
14	1300	1·722	·138	
15	1350	1·942		
16	1400	2·162		
17	1450	2·472		
18	1500	2·842	·818	

Results of Exp. XL.

Here the weight (w) at the limit of elasticity is 1160 lbs., and the corresponding deflection (δ) is 1·402.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) =·001303.

By formula (7).—The mean value of the modulus of elasticity (E) =30,211,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 30,764,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 67·763.

By formula (9).—Work of deflection (u) for unity of section = 65·131.

By formula (12).—Value of C, the unit of working strength = 6·576 tons.

TRANSVERSE STRAIN.

Exp. XLI.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Dimension of bar 1·02 inch square. Length between supports 4 feet 6 inches. Mark on bar, "F."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·123	....	Specimen of steel used in the manufacture of punches.
2	200	·242		
3	300	·396		
4	400	·487		
5	500	·605		
6	600	·735		
7	700	·866	·000	
8	800	·976	·000	
9	950	1·156	·015	
10	1100	1·426	·099	
11	1150	1·616	·169	
12	1300	2·266	·555	
13	1400	2·876	·982	Disabled.

Results of Exp. XLI.

Here the weight (w) at the limit of elasticity is 960 lbs., and the corresponding deflection (δ) is 1·156.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·001302.

By formula (7).—The mean value of the modulus of elasticity (E) = 30,218,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 32,480,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 46·240.

By formula (9).—Work of deflection (u) for unity of section = 44·444.

By formula (12).—Value of C, the unit of working strength = 5·440 tons.

TRANSVERSE STRAIN.

Exp. XLII.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Dimension of bar ·995 inch square. Length between supports 4 feet 6 inches. Mark on bar, "G."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·141		Specimen of steel used in the manufacture of Mint dies.
2	200	·280		
3	300	·410		
4	400	·541	·009	
5	500	·672	·010	
6	600	·805		
7	700	·950		
8	800	1·070	·009	
9	900	1·210		
10	950	1·290	·011	
11	1050	1·520		
12	1100	2·250	·735	
13	1150	3·280	1·627	Sunk under load.

Results of Exp. XLII.

Here the weight (w) at the limit of elasticity is 960 lbs., and the corresponding deflection (δ) is 1·290.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·001295.

By formula (7).—The mean value of the modulus of elasticity (E) = 30,398,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 31,325,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 51·600.

By formula (9).—Work of deflection (u) for unity of section = 52·120.

By formula (12).—Value of C, the unit of working strength = 5·161 tons.

TRANSVERSE STRAIN.

Exp. XLIII.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Dimension of bar 1·012 inch square. Length between supports 4 feet 6 inches. Mark on bar, "H."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·150	....	Specimen of steel used in the manufacture of dies.
2	200	·282		
3	300	·406		
4	400	·533	·011	
5	500	·653	·016	
6	600	·782		
7	700	·910	·021	
8	800	1·050		
9	900	1·190		
10	950	1·270	·021	
11	1000	1·350		
12	1050	1·470	·099	
13	1100	1·720	·249	
14	1150	2·000	·432	
15	1200	2·390		
16	1250	2·820	·995	Disabled.

Results of Exp. XLIII.

Here the weight (w) at the limit of elasticity is 960 lbs., and the corresponding deflection 1·270.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·001382.

By formula (7).—The mean value of the modulus of elasticity (E) = 28,484,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 27,542,000.

By formula (8).—The work of deflection (U) up to the limit of elasticity = 50·800.

By formula (9).—Work of deflection (u) for unity of section = 49·602.

By formula (12).—Value of C, the unit of working strength = 5·570 tons.

TRANSVERSE STRAIN.

Exp. XLIV.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Dimension of bar ·98 inch square. Length between supports 4 feet 6 inches. Mark on bar, "I."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·170	....	Specimen of steel used in the manufacture of taps.
2	200	·310		
3	300	·455		
4	400	·604	·012	
5	500	·746	·013	
6	600	·900		
7	700	1·040	·012	
8	800	1·190	·018	
9	900	1·390	·030	
10	950	1·530	·094	
11	1000	1·900	·349	
12	1050	2·460	·747	Disabled.

Results of Exp. XLIV.

Here the weight (w) at the limit of elasticity is 910 lbs., and the corresponding deflection (δ) is 1·390

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·001368.

By formula (7).—The mean value of the modulus of elasticity (E) = 31,198,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 27,646,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 52·704.

By formula (9).—Work of deflection (u) for unity of section = 54·877.

By formula (12).—Value of C, the unit of working strength = 5·788 tons.

TRANSVERSE STRAIN.

Exp. XLV.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Dimension of bar 1·022 inch square. Length between supports 4 feet 6 inches. Mark on bar, "U."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	100	·127	....	Specimen of double shear steel.
2	200	·256		
3	300	·372		
4	400	·492	·007	
5	500	·604	·010	
6	600	·730		
7	700	·866	·010	
8	800	·986	·011	
9	950	1·216	·034	
10	1000	1·316		
11	1050	1·436	·113	
12	1100	1·696	·277	
13	1150	2·136	·601	
14	1200	2·506		
15	1250	3·216	1·420	

Results of Exp. XLV.

Here the weight (w) at the limit of elasticity is 810 lbs., and the corresponding deflection (δ) is ·986.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·001325.

By formula (7).—The mean value of the modulus of elasticity (E) = 29,710,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 31,232,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 33·277.

By formula (9).—Work of deflection (u) for unity of section = 31·859.

By formula (12).—Value of C, the unit of working strength = 4·561 tons.

Exp. XLVI.—Bar of Steel from the Titanic Steel Co., Worcester. Dimension of bar 1·004 inch square. Length between supports 4 feet 6 inches. Mark on bar, "A X."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·065	....	This steel is intended for rods, plates, and girders.
2	75	·095		
3	100	·133		
4	125	·163		
5	150	·195		
6	175	·231		
7	200	·258		
8	225	·292		
9	250	·313		
10	300	·383		
11	350	·449		
12	400	·508		We have no particulars of the properties of this metal. It is one of our best specimens.
13	450	·569		
14	500	·632		
15	550	·692		
16	600	·754		
17	650	·839		
18	700	·889		
19	750	·969		
20	800	·999		
21	850	1·079		
22	900	1·129		
23	950	1·199		
24	1000	1·279		
25	1050	1·369		
26	1100	1·389		
27	1150	1·449		
28	1200	1·509		
29	1250	1·589		
30	1300	1·669	·000	
31	1350	1·739	·000	
32	1400	1·809	·000	
33	1450	1·899	·012	
34	1500	1·969	·025	
35	1600	2·319	·206	
36	1712	3·289	·855	Experiment discontinued.

Results of Exp. XLVI.

Here the weight (w) at the limit of elasticity is 1460 lbs., and the corresponding deflection (δ) is 1·899.——By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·001265.——By formula (7).—The mean value of the modulus of elasticity (E) = 31,119,000.——By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 32,120,000.——By formula (8).—The work of deflection (U) up to the limit of elasticity = 115·522.——By formula (9).—Work of deflection (u) for unity of section = 114·600.——By formula (12).—Value of C, the unit of working strength = 8·682 tons.

TRANSVERSE STRAIN.

Exp. XLVII.—Bar of Steel from the Titanic Steel Co., Worcester. Dimension of bar ·99 inch square. Length between supports 4 feet 6 inches. Mark on bar, "B X."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·062	....	Steel intended for "Wheel Tyres."
2	100	·129		
3	150	·182		
4	200	·247		
5	250	·322		
6	300	·376		
7	350	·440		
8	400	·500		
9	450	·559		
10	500	·628		
11	550	·692		
12	600	·772		
13	650	·832		
14	700	·892		
15	750	·952		
16	800	1·012		
17	850	1·092		
18	900	1·152		
19	950	1·212	·000	
20	1000	1·232	·008	
21	1050	1·382	·027	
22	1100	1·482	·078	
23	1150	1·612	·142	
24	1200	2·172	·596	
25	1250	3·042	1·446	Experiment discontinued.

Results of Exp. XLVII.

Here the weight (w) at the limit of elasticity is 1010 lbs., and the corresponding deflection (δ) is 1·232.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·001177.

By formula (7).—The mean value of the modulus of elasticity (E) = 33,446,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 34,935,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 51·846.

By formula (9).—Work of deflection (u) for unity of section = 52·892.

By formula (12).—Value of C, the unit of working strength = 6·621 tons.

TRANSVERSE STRAIN.

Exp. XLVIII.—Bar of Steel from the Titanic Steel Co., Worcester. Dimension of bar 1·002 inch square. Length between supports 4 feet 6 inches. Mark on bar, "C X."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·062	....	Steel intended for general purposes.
2	100	·123		
3	150	·185		
4	200	·256		
5	250	·319		
6	300	·376		
7	350	·443		
8	400	·505		
9	450	·572		
10	500	·631		
11	550	·692		
12	600	·752		
13	650	·829		
14	700	·889		
15	750	·959		
16	800	1·029		
17	850	1·119		
18	900	1·169	·000	
19	950	1·249	·004	
20	1000	1·329	·032	
21	1050	1·459	·099	
22	1100	1·719	·282	
23	1150	1·899	1·296	Experiment discontinued.

Results of Exp. XLVIII.

Here the weight (w) at the limit of elasticity is 960 lbs., and the corresponding deflection (δ) is 1·249.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·001237.

By formula (7).—The mean value of the modulus of elasticity (E) = 31,823,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 34,879,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 49·960.

By formula (9).—Work of deflection (u) for unity of section = 49·76.

By formula (12).—Value of C, the unit of working strength = 5·739 tons.

TRANSVERSE STRAIN.

Exp. XLIX.—Bar of Steel from the Titanic Steel Co., Worcester. Dimension of bar 1·008 inch square. Length between supports 4 feet 6 inches. Mark on bar, "D X."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·059	....	Steel intended for "Wheel Tyres."
2	100	·138		
3	150	·178		
4	200	·248		
5	250	·316		
6	300	·384		
7	350	·440		
8	400	·500		
9	450	·559		
10	500	·621		
11	550	·687		
12	600	·748		
13	650	·808		
14	700	·878		
15	750	·938		
16	800	1·018	·000	
17	850	1·098	·018	
18	900	1·188	·046	
19	950	1·348	·159	
20	1000	3·308	1·997	Experiment discontinued.

Results of Exp. XLIX.

Here the weight (w) at the limit of elasticity is 860 lbs., and the corresponding deflection (δ) is 1·098.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·001261.

By formula (7).—The mean value of the modulus of elasticity (E) = 31,218,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 30,418,000.

By formula (8).—The work of deflection (U) up to the limit of elasticity = 39·345.

By formula (9).—Work of deflection (u) for unity of section = 36·915.

By formula (12).—Value of C, the unit of working strength = 4·699 tons.

TRANSVERSE STRAIN.

Exp. L.—Bar of Steel from the Barrow Hæmatite Co., Furness. Dimension of bar 1·02 inch square. Length between supports 4 feet 6 inches. Mark on bar, "H 1."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·065	....	Hard steel.
2	100	·118		
3	150	·179		
4	200	·240		
5	250	·309		
6	300	·364		
7	350	·426		
8	400	·491		
9	450	·555		
10	500	·611		
11	550	·676		
12	600	·742		
13	650	·803		
14	700	·866		
15	750	·946		
16	800	1·006		
17	850	1·076		
18	900	1·146		
19	950	1·206		
20	1000	1·266		
21	1050	1·346		
22	1100	1·406	·000	
23	1150	1·476	·000	
24	1200	1·546	·016	
25	1250	1·646	·055	
26	1300	1·796	·133	
27	1350	2·156	·429	
28	1400	2·746	·883	Experiment discontinued.

Results of Exp. L.

Here the weight (w) at the limit of elasticity is 1210 lbs., and the corresponding deflection (δ) is 1·546.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·001308.

By formula (7).—The mean value of the modulus of elasticity (E) = 30,096,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 33,830,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 77·944.

By formula (9).—Work of deflection (u) for unity of section = 77·917.

By formula (12).—Value of C, the unit of working strength = 6·860 tons.

TRANSVERSE STRAIN.

EXP. LI.—Bar of Steel from the Barrow Hæmatite Co., Furness. Dimension of bar ·995 inch square. Length between supports 4 feet 6 inches. Mark on bar, "H 2."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·065	....	Soft steel.
2	100	·128		
3	150	·201		
4	200	·266		
5	250	·330		
6	300	·396		
7	350	·466		
8	400	·534		
9	450	·601		
10	500	·682	·000	
11	550	·760	·027	
12	600	·880	·052	
13	650	1·020	·115	
14	700	2·040	1·068	
15	750	....	..	Destroyed.

Results of Exp. LI.

Here the weight (w) at the limit of elasticity is 510 lbs., and the corresponding deflection (δ) is ·682.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1)=·001280.

By formula (7).—The mean value of the modulus of elasticity (E) =30,754,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure=34,443,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity =14·242

By formula (9).—Work of deflection (u) for unity of section=14·383.

By formula (12).—Value of (C), the unit of working strength=3·108 tons.

TRANSVERSE STRAIN.

Exp. LII.—Bar of Steel from the Barrow Hæmatite Co., Furness. Dimension of bar 1·01 inch square. Length between supports 4 feet 6 inches. Mark on bar, "H 3."

No. of Exp.	Weight laid on, in lbs.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1	50	·074	....	Soft steel.
2	100	·127		
3	150	·195		
4	200	·262		
5	250	·330		
6	300	·395		
7	350	·453		
8	400	·515		
9	450	·577	·000	
10	500	·645	·007	
11	550	·716	·018	
12	600	·793	·019	
13	650	·873	·032	
14	700	1·029	·118	
15	750	1·279	·287	
16	800	2·709	1·625	Experiment discontinued.

Results of Exp. LII.

Here the weight (w) at the limit of elasticity is 610 lbs., and the corresponding deflection (δ) is ·793.

By formula (6).—The mean value of the deflection for unity of pressure and section (D_1) = ·001319.

By formula (7).—The mean value of the modulus of elasticity (E) = 29,717,000.

By formula (2).—The modulus of elasticity (E) corresponding to 112 lbs. pressure = 32,717,000.

By formula (8).—Work of deflection (U) up to the limit of elasticity = 20·155.

By formula (9).—Work of deflection (u) for unity of section = 19·757.

By formula (12).—Value of C, the unit of working strength = 3·540 tons.

TABLE I.—Summary of Results of the Experiments on Transverse Strain.

No. of Exp.	Manufacturers.	Mark on Bar.	Mean value (D_1) of the deflection for unity of pressure and section. By eq. (6).	Mean value of the modulus of elasticity (E). By eq. (7).	Modulus of elasticity corresponding to 112 lbs. pressure. By eq. (2).	Work of deflection (U) up to the limit of elasticity. By eq (8).	Work of deflection (u) for unity of section. By eq. (9).	Value C, the unit of working strength. By eq. (12).	Remarks.
	Messrs. BROWN AND Co.							tons.	
1	Best cast steel from Russian and Swedish iron, for turning-tools	B 1	·0012048	32,672,000	33,047,000	52·280	55·563	6·326	Sunk with 1150 lbs.
2	Ditto, milder	B 2	·0013377	29,415,000	29,465,000	59·280	63·003	6·326	"
3	Cast steel from Swedish iron, for tools	B 3	·0012891	30,550,000	32,171,000	72·838	72·690	6·958	"
4	Ditto, milder, for chisels	B 4	·0012581	29,463,000	29,370,000	52·720	54·893	6·134	"
5	Ditto, mild, for welding	B 5	·0012673	29,248,000	31,510,000	53·480	55·865	6·134	"
6	Bessemer steel	B 6	·0013024	30,224,000	32,361,000	42·068	42·749	5·297	Sunk with 950 lbs.
7	Specimen of double shear steel from Swedish iron	B 7	·0012643	31,135,000	33,523,000	43·900	45·897	5·527	"
8	Do. do. foreign bar, tilted direct.	B 8	·0012863	29,335,000	30,686,000	43·358	44·598	5·394	"
9	English tilted steel made from English and foreign pigs	B 9	·0012580	31,292,000	31,833,000	39·416	39·416	5·170	"
	C. CAMMELL AND Co.								
10	Specimen of cast steel, termed "Diamond Steel"	1	·0013081	30,088,000	29.996,000	95·000	85·515	7·504	
11	Do. steel, termed "Tool Steel"	2	·0016370	22,965,000	24,288,000	102·443	84·048	5·904	
12	Do. cast steel, termed "Chisel Steel"	3	·0012612	31,212,000	31,474,000	77·864	78·825	7·413	
13	Do. do. termed "Double Shear Steel"	4	·0013254	29,700,000	30,126,000	44·240	40·902	5·132	
14	Bar of hard Bessemer steel	5	·0012805	30,742,000	33,205,000	33·750	32·439	4·588	Sunk with 950 lbs.
15	Do. soft do.	6	·0012995	30,291,000	31,056,000	37·057	37·657	4·988	"
	NAYLOR AND VICKERS.								
16	Cast steel called "Axle Steel"	A	·0012730	30,923,000	30,940,000	44·741	44·741	5·742	Sunk with 1150 lbs.
17	Do. do. "Tyre Steel"	T	·0013124	29,994,000	27,847,000	40·025	40·184	5·505	"
18	Do. do. "Vickers' Cast Steel, Special"	S	·0013386	29,407,000	29,385,000	99·463	94·485	7·856	
19	Do. do. "Naylor and Vickers' Cast Steel"	S 26	·0012789	30,788,000	29,752,000	82·412	80·788	7·358	
	S. OSBORN.								
20	Specimen of best tool, cast steel	1	·0013886	28,353,000	26,689,000	50·668	48·813	5·432	
21	Do. chisel do.	2	·0012780	30,802,000	30,523,000	64·195	62·684	6·400	
22	Sates-cup, shear-blades, and boiler-maker's steel	3	·0017814	22,098,000	22,072,000	54·287	47·845	4·691	Sunk with 1300 lbs.

23	Best cast steel for taps and dies	4	·0013409	29,368,000	29,718,000	56·433	56·435	6·037	Sunk with 1250 lbs.
24	Toughened cast steel for shafts, &c.	5	·0013112	26,398,000	29,610,000	50·079	53·194	5·559	Sunk with 1300 lbs.
25	Specimen of best double shear steel	6	·0016881	23,319,000	23,948,000	31·792	29·393	4·329	Sunk with 1200 lbs.
26	Extra best tool, cast steel	7	·0013480	29,188,000	28,013,000	75·776	72·826	6·860	Sunk with 1300 lbs.
27	Cast steel for boiler-plates	8	·0013007	30,335,000	29,585,000	50·000	49·406	5·671	"
	H. Bessemer.								
28	Specimen of hard Bessemer steel	BS1	·0021814	29,652,000	29,104,000	70·762	72·199	6·882	
29	Do. milder do.	BS2	·0012946	30,478,000	28,379,000	42·087	42·261	5·317	Sunk with 1100 lbs.
30	Do. soft do.	BS3	·0015293	29,310,000	28,536,000	32·364	35·008	4·778	Sunk with 850 lbs.
	Sanderson Brothers.								
31	Bar of cast steel from Russian iron, suitable for welding	S1	·0012822	30,700,000	31,482,000	52·116	47·452	5·539	
32	Specimen of double shear steel	S2	·0013412	29,351,000	28,074,000	39·443	37·022	4·808	Sunk with 1350 lbs.
33	Do. single do.	S3	·0012963	30,368,000	29,858,000	71·390	68·082	6·780	
34	Bar of faggot steel, welded	S4	·0013516	29,922,000	29,184,000	51·675	47·230	5·572	
35	Specimen of drawn bar, not welded	S5	·0013333	29,524,000	28,179,000	40·078	37·269	4·907	Sunk with 1200 lbs.
	Messrs. Turton and Sons.								
36	Steel intended for the manufacture of cups	A	·0013033	30,204,000	30,895,000	46·400	45·369	5·392	Sunk with 1150 lbs.
37	Do. do. drills	B	·0012953	30,390,000	31,297,000	71·087	66·748	6·625	
38	Do. do. cutters	C	·0012598	31,247,000	31,859,000	65·443	65·705	6·718	
39	Do. do. turning tools	D	·0012870	30,887,000	32,462,000	59·253	60·949	6·337	Sunk with 1250 lbs.
40	Do. do. machinery	E	·0013030	30,211,000	30,764,000	67·763	65·131	6·576	
41	Do. do. punches	F	·0013020	30,218,000	32,480,000	46·240	44·444	5·440	
42	Do. do. mint dies	G	·0012950	30,398,000	31,325,000	51·600	52·120	5·861	Sunk with 1150 lbs.
43	Do. do. dies	H	·0013820	28,484,000	27,542,000	50·800	49·602	5·570	Sunk with 1250 lbs.
44	Do. do. taps	I	·0013680	31,198,000	27,646,000	52·704	54·877	5·788	Sunk with 1050 lbs.
45	Specimen of double shear steel	U	·0013250	29,710,000	31,232,000	33·277	31·859	4·561	Sunk with 1250 lbs.
	Titanic Steel Company.								
46	Steel intended for rods, plates, and girders	AX	·0012650	31,119,000	32,120,000	115·522	114·600	8·682	
47	Do. wheel tyres	BX	·0011770	33,446,000	34,935,000	51·846	52·892	6·621	
48	Do. general purposes	CX	·0012370	31,823,000	34,879,000	49·960	49·760	5·739	
49	Do. wheel tyres	DX	·0012610	31,218,000	30,418,000	39·345	36·915	4·699	
	Hæmatite Steel Company.								
50	There is some uncertainty about these bars. The	H1	·001308	30,096,000	33,830,000	77·944	77·917	6·860	
51	experiments will be repeated on new bars direct	H2	·001280	30,754,000	34,443,000	14·242	14·383	3·108	
52	from the Barrow Works	H3	·001319	29,717,000	32,717,000	20·155	19·757	3·540	

From the above Summary of Results may be taken almost every description of steel manufactured for the purposes of construction, when subjected to a transverse strain. The utmost care has been taken to work out the conditions and properties of the specimens; and assuming that these conditions would be fulfilled by the manufacturer, the engineer, the architect, or the builder, he could have no difficulty in selecting such material as he may require in the varied forms of constructions and uses for which it is intended.

It will be observed that in every description of manufacture, and in every description of each manufacture, the whole of the transverse properties have been determined, both as regards the modulus of elasticity and deflection, and the measure of work done (as indicated by the unit of working strength, which will be found in the last column). The deflections up to the limit of weights laid on, as also for unity of section, will be found in the fourth and fifth columns.

It might have been desirable to have received from the makers more extended information as regards the different processes of conversion, and the quality of the ores, crude iron, &c. from which the specimens were obtained; these with the chemical constituents of the material would have been highly valuable. But in my endeavours to arrive at correct results, much had to be left to the discretion of those who selected the samples, and to the honesty of purpose by which they were guided in the selection. It is only natural that the manufacturer should select samples from which the best results would be obtained, in order that he might in every test stand high in the scale of utility. On the other hand, it must be observed that it is not the material of the greatest density and strength that is required on all occasions; on the contrary, it is quite the reverse for many purposes, as in some cases it is essential to have the metal soft and ductile, easily worked, and convertible into shapes where its flexibility would be important. Again, any hard brittle steel capable of retaining a fine edge is of inestimable use for tools, but it is totally inapplicable to structural purposes, where elasticity and strength is required for endurance. All these are points which I have endeavoured to attain and simplify in the experiments, and having indicated their properties in the above Summary on Transverse Strain, we now proceed to those which refer to tension.

In submitting wrought iron or steel bars to a transverse strain, the same results are not obtained as in cast iron, as bars 4 feet 6 inches long of the former material will bend or deflect through a depth of some feet before fracture ensues, the deflections in this case being equivalent to a permanent set nearly equal to the deflection. Under these conditions, when the permanent set arrives at one-half the amount of the deflection, I have considered the resisting powers of the bars so much injured as to render any additional strain of no practical value. In the case of steel bars of greater density and hardness, the same law between the deflection and the permanent set does not exist, and hence the difference of elasticity in the different kinds of steel of which the bars are composed. To remedy these discrepancies and effect a comparison between the different qualities of the material, it was necessary to fix some limitation to the weights laid on, and to ascertain the point of strain corresponding to the elastic limit,—which in the calculations is that point where the deflection is not in excess of what the law of deflection (viz. in proportion to the strain) would indicate, whilst the next greater strain gives a deflection decidedly in excess of that law. This is, however, clearly explained in the abstract of results.

A very slight variation in the observed deflection at the commencement of the experiments before the bar had got its natural set would increase the difficulty of ascertaining the correct permanent set corresponding to very limited strains. We all know when a bar is a little bent we can make it straight by hammering or by pressure, but the probability is that the first form is the natural disposition of the material.

This principle is adopted in the calculations, as the elasticity of a bar is impaired when the deflection decidedly exceeds what the law of deflection would give. After the elastic limit is passed the deflections increase in a geometric progression, whereas up to that limit the deflections are in proportion to the strain.

One of the marked peculiarities of steel as compared with iron is, that the strain corresponding to the elastic limit approaches more nearly the breaking strain. Hence will be found the comparative high value of the constant C, or the unit of pressure determined for the bars. A load of one-third the breaking weight has always been considered a safe rule, but it is only conventional; but there is something still wanting relative to the point of strain corresponding to the injury done to the material, as the inference drawn from the Tables indicates that the strain producing the permanent set had not seriously affected the soundness of the bars. This is a question of considerable importance, and requires further investigation, which I hope to accomplish at some future time.

SECOND SERIES OF EXPERIMENTS.

TENSILE STRAIN.

Exp. I.—Bar of Steel from Messrs. Brown & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "B 1." Diameter of specimen ·77 inch. Area ·4656 square inch. Reduced diameter after fracture ·77 inch. Area ·4656 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	22009	....	....	·0018	....	Specimen of best cast steel from Russian and Swedish iron. Used for turning-tools.
2	25369	....	....	·0018		
3	28729	....	....	·0031		
4	30304	....	....	·0056		
5	31849	68404	30·53	....	·0025	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 68,404 lbs., or 30·53 tons; and the corresponding elongation (l_1) per unit of length is ·0056. By formula (13).—The work (u) expended in producing rupture = 191.

Exp. II.—Bar of Steel from Messrs. Brown & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "B 2." Diameter of specimen ·744 inch. Area ·4347 square inch. Reduced diameter after fracture ·74 inch. Area ·43 square inch.

No. of Exp.	Weight laid on.	Breaking strain per. square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	10249	....	....	....	....	Specimen of best cast steel from Russian and Swedish iron, of milder quality than No. 1. Used for chisels &c.
2	13609	....	....			
3	16969	....	....			
4	18649	....	....			
5	20329	....	....			
6	23689	....	....			
7	25369	....	....	·0012		
8	27049	....	....	·0012		
9	28729	....	....	·0012		
10	30304	....	....	·0012		
11	31879	....	....	·0012		
12	33439	....	....	·0087		
13	36664	....	....	·0118		
14	38224	....	....	·0275		
15	39784	91520	40·85	....	·0150	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 91,520 lbs., or 40·85 tons; and the corresponding elongation (l_1) per unit of length is ·0275. By formula (13).—The work (u) expended in producing rupture=686.

Exp. III.—Bar of Steel from Messrs. Brown & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "B 3." Diameter of specimen ·602 inch. Area ·2846 square inch. Reduced diameter after fracture ·602 inch. Area ·2846 square inch.

1	10451	....	....	....	....	Specimen of cast steel from Swedish iron; for tools, &c.
2	12131	....	....	·0006		
3	13811	....	....	·0012		
4	15494	....	....	·0012		
5	17171	....	....	·0031		
6	18851	....	....	·0031		
7	20531	....	....	·0037		
8	22211	....	....	·0044		
9	23891	....	....	·0044		
10	25571	....	....	·0044		
11	27146	....	....	·0050		
12	28796	....	....	·0143		
13	30871	106714	47·64	....	·0100	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 106,714 lbs., or 47·64 tons; and the corresponding elongation (l_1) per unit of length is ·0143. By formula (13).—The work (u) expended in producing rupture=763.

Exp. IV.—Bar of Steel from Messrs. Brown & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "B 4." Diameter of specimen ·737 inch. Area ·4266 square inch. Reduced diameter after fracture ·726 inch. Area ·4139 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	25369	....	....	·0001	....	Specimen of cast steel from Swedish iron, of milder quality than No. 3. Used for chisels.
2	28729	....	....	·0012		
3	31849	....	....	·0025		
4	33439	....	....	·0037		
5	35014	....	....	·0118		
6	36664	....	....	·0125		
7	38224	....	....	·0150		
8	39784	....	....	·0181		
9	41344	....	....	·0193		
10	42904	....	....	·0231		
11	44464	....	....	·0262		
12	46249	....	....	·0293		
13	47959	....	....	·0337		
14	49564	116183	51·86	....	·0362	Broke in neck.

Results—Here the breaking strain (P_1) per square inch of section is 116,183 lbs., or 51·86 tons; and the corresponding elongation (l_1) per unit of length is ·0337. By formula (13).—The work (u) expended in producing rupture = 1957.

Exp. V.—Bar of Steel from Messrs. Brown & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "B 5." Diameter of specimen ·608 inch. Area ·29 square inch. Reduced diameter after fracture ·60 inch. Area ·2827 square inch.

1	10249	....	....	....	....	Specimen of steel cast from Swedish iron, of mild quality for welding.
2	11929					
3	13609					
4	15289					
5	16969	....	....	·0006		
6	18649	....	....	·0060		
7	20329	....	....	·0087		
8	22009	....	....	·0137		
9	23689	....	....	·0168		
10	25369	....	....	·0187		
11	27049	....	....	·0250		
12	28729	....	....	·0300		
13	30371	....	....	·0375		
14	31916	110055	49·13	....	·0331	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 110,055 lbs., or 49·13 tons; and the corresponding elongation (l_1) per unit of length is ·0375. By formula (13).—The work (u) expended in producing rupture = 2063.

Exp. VI.—Bar of Steel from Messrs. Brown & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "B 6." Diameter of specimen ·742 inch. Area ·4324 square inch. Reduced diameter after fracture ·525 inch. Area ·2164 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	10249	....	....	·0012	....	Bar of Bessemer steel.
2	18649	....	....	·0025		
3	25369	....	....	·0043		
4	27049	....	....	·0187		
5	28729	....	....	·0275		
6	30304	....	....	·0325		
7	31849	....	....	·0387		
8	33439	....	....	·0475		
9	35014	....	....	·0612		
10	36664	....	....	·0650		
11	38224	....	....	·0837		
12	39764	91972	41·05	....	·1962	

Results.—Here the breaking strain (P_1) per square inch of section is 91,972 lbs., or 41·05 tons; and the corresponding elongation (l_1) per unit of length is ·0837. By formula (13).—The work (u) expended in producing rupture = 4522.

Exp. VII.—Bar of Steel from Messrs. Brown and Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "B 7." Diameter of specimen ·74 inch. Area ·43 square inch. Reduced diameter after fracture ·72 inch. Area ·4071 square inch.

1	22009	....	....	·0012	....	Specimen of double shear steel from Swedish bar.
2	25369	....	....	·0018		
3	28729	....	....	·0143		
4	30304	....	....	·0175		
5	31849	....	....	·0200		
6	33439	....	....	·0218		
7	35014	....	....	·0268		
8	36664	....	....	·0300		
9	38224	....	....	·0406		
10	39799	92555	41·31	....	·0543	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 92,555 lbs., or 41·31 tons; and the corresponding elongation (l_1) per unit of length is ·0406. By formula (13).—The work (u) expended in producing rupture = 1878.

Exp. VIII.—Bar of Steel from Messrs. Brown & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "B 8." Diameter of specimen ·607 inch. Area=·2893 square inch. Reduced diameter after fracture ·555 inch. Area ·242 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length. Elongation.	Per unit of length. Permanent set.	Remarks.
	lbs.	lbs.	tons.			
1	10451	....	....	·0000	....	Specimen of "foreign bar" not melted, but tilted direct.
2	12131	....	....	·0000		
3	13811	....	....	·0087		
4	15491	....	....	·0250		
5	17171	....	....	·0362		
6	18851	....	....	·0518		
7	20531	....	....	·0968		
8	22211	76774	34·27	....	·1356	Broke 1 inch from [neck.

Results.—Here the breaking strain (P_1) per square inch of section is 76,774 lbs., or 34·27 tons; and the corresponding elongation (l_1) per unit of length is ·0968. By formula (13).—The work (u) expended in producing rupture=3715.

Exp. IX.—Bar of Steel from Messrs. Brown & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "B 9." Diameter of specimen ·606 inch. Area ·2884 square inch. Reduced diameter after fracture ·41 inch. Area ·132 square inch.

1	10451	....	....	·0143	....	Specimen of (B) bar. English tilted steel, made from English and foreign pigs.
2	12131	....	....	·0275		
3	13811	....	....	·0412		
4	15494	....	....	·0762		
5	17171	59538	26·57	....	·2106	Broke in the centre.

Results.—Here the breaking strain (P_1) per square inch of section is 59,538 lbs., or 26·57 tons; and the corresponding elongation (l_1) per unit of length is ·0762. By formula (13).—The work (u) expended in producing rupture=2268.

Exp. X.—Bar of Steel from Messrs. Cammell & Co., Sheffield. Elongations taken on 8·5 inches length. Mark on bar, "1." Diameter of specimen ·608 inch. Area ·29 square inch. Reduced diameter after fracture ·606 inch. Area ·2884 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	10451	....	....	....	....	Specimen of cast steel, termed "Diamond Steel."
2	12131					
3	13811					
4	15491	....	....	·0000		
5	17171	....	....	·0005		
6	18851	....	....	·0005		
7	20531	....	....	·0005		
8	22211	....	....	·0005		
9	23891	....	....	·0005		
10	25571	....	....	·0011		
11	27146	....	....	·0118		
12	28796	....	....	·0160		
13	30341	....	....	·0177		Held this weight ½ a minute, and broke 2½ ins. from neck.
14	31916	110055	49·13	....	·0153	

Results.—Here the breaking strain (P_1) per square inch of section is 110,055 lbs., or 49·13 tons; and the corresponding elongation (l_1) per unit of length is ·0177. By formula (13).—The work (u) expended in producing rupture = 974.

Exp. XI.—Bar of Steel from Messrs. Cammell & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "2." Diameter of specimen ·61 inch. Area ·2922 square inch. Reduced diameter after fracture ·605 inch. Area ·2874 square inch.

1	10451	....	....	....	....	Specimen of steel termed "Tool Steel."
2	12151					
3	13811					
4	15491					
5	17171					
6	18851	....	....	·0025		
7	20531	....	....	·0025		
8	22211	....	....	·0025		
9	23891	....	....	·0025		
10	25571	....	....	·0025		
11	27131	....	....	·0150		
12	28706	....	....	·0150		
13	30281	....	....	·0206		
14	31871	109072	48·69	....	·0150	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 109,072 lbs., or 48·69 tons; and the corresponding elongation (l_1) per unit of length is ·0206. By formula (13).—The work (u) expended in producing rupture = 1123.

Exp. XII.—Bar of Steel from Messrs. Cammell & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "3." Diameter of specimen ·609 inch. Area ·2912 square inch. Reduced diameter after fracture ·605 inch. Area ·2874 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	10451	....	....	·0018	....	Specimen of cast steel, termed "Chisel Steel."
2	12131	....	....	·0018		
3	13811	....	....	·0018		
4	15494	....	....	·0018		
5	17171	....	....	·0018		
6	18851	....	....	·0025		
7	20531	....	....	·0025		
8	22211	....	....	·0037		
9	23891	....	....	·0050		
10	25571	....	....	·0143		
11	27221	....	....	·0162		
12	28796	....	....	·0194		
13	30371	....	....	·0217		
14	31916	....	....	·0243		
15	33506	....	....	·0281		
16	35066	120398	53·75	....	·0250	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 120,398 lbs., or 53·75 tons; and the corresponding elongation (l_1) per unit of length is ·0281. By formula (13).—The work (u) expended in producing rupture=1691.

Exp. XIII.—Bar of Steel from Messrs. Cammell & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "4." Diameter of specimen ·738 inch. Area ·4277 square inch. Reduced diameter after fracture ·729 inch. Area ·4173 square inch.

1	25369	....	....	·0025	....	Specimen of cast steel, termed "Double Shear Steel."
2	28729	....	....	·0081		
3	30304	....	....	·0100		
4	31849	....	....	·0137		
5	33439	....	....	·0150		
6	35014	....	....	·0162		
7	36664	....	....	·0187		
8	38224	....	....	·0218		
9	39784	....	....	·0250		
10	41344	96665	43·15	....	·0237	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 96,665 lbs., or 43·15 tons; and the corresponding elongation (l_1) per unit of length is ·0250. By formula (13).—The work (u) expended in producing rupture=1208.

Exp. XIV.—Bar of Steel from Messrs. Cammell & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "5." Diameter of specimen ·739 inch. Area ·4289 square inch. Reduced diameter after fracture ·511 inch. Area ·2042 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	25369	....	....	·0206	....	Bar of hard Bessemer steel.
2	27049	....	....	·0268		
3	28729	....	....	·0337		
4	30304	....	....	·0543		
5	31849	....	....	·0687		
6	33439	....	....	·0700		
7	35014	....	....	·0937		
8	36664	....	....	·1437		
9	38224	89121	39·78	....	·2087	Broke near centre.

Results.—Here the breaking strain (P_1) per square inch of section is 89,121 lbs., or 39·78 tons; and the corresponding elongation (l_1) per unit of length is ·1437. By formula (13).—The work (u) expended in producing rupture = 6403.

Exp. XV.—Bar of Steel from Messrs. Cammell & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "6." Diameter of specimen ·611 inch. Area ·2932 square inch. Reduced diameter after fracture ·391 inch. Area ·12 square inch.

1	10451	....	....	....	....	Bar of soft Bessemer steel.
2	12131	....	....			
3	13811	....	....			
4	15491	....	....	·0000		
5	17171	....	....	·0056		
6	18851	....	....	·0331		
7	20531	....	....	·0743		
8	22211	....	....	·1200		
9	23891	81483	36·37	....	·2043	Broke near centre.

Results.—Here the breaking strain (P_1) per square inch of section is 81,483 lbs., or 36·37 tons; and the corresponding elongation (l_1) per unit of length is ·1200. By formula (13).—The work (u) expended in producing rupture = 4888.

Exp. XVI.—Bar of Steel from Messrs. Naylor, Vickers & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "Axle Steel." Diameter of specimen ·606 inch. Area ·2884 square inch. Reduced diameter after fracture ·44 inch. Area ·152 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	10451	....	....	·0031	....	Specimen of cast steel, converted in the crucible, from bar-iron with the addition of manganese.
2	12131	....	....	·0031		
3	13811	....	....	·0031		
4	15491	....	....	·0031		
5	17171	....	....	·0031		
6	18851	....	....	·0218		
7	20531	....	....	·0300		
8	22211	....	....	·0412		
9	23891	....	....	·0625		
10	25571	88665	39·58	....	·1625	Broke in centre.

Results.—Here the breaking strain (P_1) per square inch of section is 88,665 lbs., or 39·58 tons; and the corresponding elongation (l_1) per unit of length is ·0625. By formula (13).—The work (u) expended in producing rupture = 2270.

Exp. XVII.—Bar of Steel from Messrs. Naylor, Vickers & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "V T." Diameter of specimen ·744 inch. Area ·4347 square inch. Reduced diameter after fracture ·53 inch. Area ·2206 square inch.

1	18649	....	....	....	....	Specimen of cast steel, converted in the crucible, from bar-iron with the addition of manganese.
2	25369	....	....			
3	27049	....	....	·0031		
4	28729	....	....	·0068		
5	30304	....	....	·0100		
6	31849	....	....	·0150		
7	33439	....	....	·0225		
8	35014	....	....	·0287		
9	36664	....	....	·0362		
10	38224	....	....	·0475		
11	39784	91520	40·85	....	·0900	Broke $2\frac{3}{4}$ in. from neck.

Results.—Here the breaking strain (P_1) per square inch of section is 91,520 lbs., or 40·85 tons; and the corresponding elongation (l_1) per unit of length is ·0475. By formula (13).—The work (u) expended in producing rupture = 2173.

Exp. XVIII.—Bar of Steel from Messrs. Naylor, Vickers & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "V S." Diameter of specimen ·738 inch. Area ·4277 square inch. Reduced diameter after fracture ·734 inch. Area ·4231 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	25369	....	......	....	....	Specimen of cast steel, converted in the crucible, from bar-iron with the addition of manganese.
2	27049					
3	28729					
4	30304					
5	31849					
6	33439					
7	35014					
8	36664					
9	38224	....	....	·0006		
10	39784	....	....	·0012		
11	41344	....	....	·0014		
12	42904	....	....	·0018		
13	44464	....	....	·0020		
14	46054	....	....	·0025		
15	47764	....	....	·0037		
16	49549	....	....	·0050		
17	51619	....	....	·0069		
18	53525	....	....	·0093		Held this weight 15 seconds, and then broke.
19	55414	....	....	·0100		
20	57374	134145	59·87	....	·0100	

Results.—Here the breaking strain (P_1) per square inch of section is 134,145 lbs., or 59·87 tons; and the corresponding elongation (l_1) per unit of length is ·0100. By formula (13).—The work (u) expended in producing rupture = 670.

Exp. XIX.—Bar of Steel from Messrs. Naylor, Vickers & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "2·66 Cast Steel." Diameter of specimen ·615 inch. Area ·297 square inch. Reduced diameter after fracture ·609 inch. Area ·2912 square inch.

1	10451	....	....	·0000	...	Specimen of cast steel, converted in the crucible, from bar-iron with the addition of manganese.
2	12131	....	...	·0016		
3	13811	....	....	·0016		
4	15491	....	....	·0016		
5	17171	....	....	·0016		
6	18851	....	....	·0016		
7	20531	....	....	·0016		
8	22211	....	....	·0016		
9	23891	....	....	·0093		
10	25571	....	....	·0093		
11	27221	....	....	·0131		
12	28796	....	....	·0150		
13	30371	....	....	·0175		
14	31960	....	....	·0275		
15	33506	....	....	·0287		
16	35066	118066	52·70	....	·0175	

Results.—Here the breaking strain (P_1) per square inch of section is 118,066 lbs., or 52·70 tons; and the corresponding elongation (l_1) per unit of length is ·0287. By formula (13).—The work (u) expended in producing rupture = 1694.

EXP. XX.—Bar of Steel from Messrs. Osborn & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "O 1." Diameter of specimen ·745 inch. Area ·4359 square inch. Reduced diameter after fracture ·739 inch. Area ·4289 square inch.

No. of Exp.	Weight laid on	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons			
1	18649	....	....	....	....	Specimen of best cast turning-tool steel.
2	22009	....	....	·0012		
3	25369	....	....	·0012		
4	27049	....	....	·0012		
5	28729	....	....	·0012		
6	30304	....	....	·0018		
7	31849	....	...	·0025		
8	35014	. ..	....	·0060		
9	36664	....	....	·0160		
10	38224	....	....	·0160		
11	39784	....	....	·0118		
12	41344	....	....	·0156		
13	43129	98942	44·17	....	·0093	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 98,942 lbs., or 44·17 tons; and the corresponding elongation (l_1) per unit of length is ·0156. By formula (13).—The work (u) expended in producing rupture = 771.

EXP. XXI.—Bar of Steel from Messrs. Osborn & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "O 2." Diameter of specimen ·731 inch. Area ·4196 square inch. Reduced diameter after fracture ·721 inch. Area ·4082 square inch.

1	25369	....	....	·0018	....	Specimen of best cast steel for cold-chipping chisels.
2	28729	....	....	·0031		
3	31849	....	....	·0068		
4	35014	....	....	·0106		
5	38224	....	....	·0143		
6	41344	....	....	·0193		
7	44464	....	....	·0238		
8	46054	....	....	·0256		
9	47764	....	....	·0275		
10	49694	....	....	·0318		
11	51899	123686	55·21	....	·0318	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 123,686 lbs., or 55·21 tons; and the corresponding elongation (l_1) per unit of length is ·0318. By formula (13).—The work (u) expended in producing rupture = 1966.

Exp. XXII.—Bar of Steel from Messrs. Osborn & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "O 3." Diameter of specimen ·738 inch. Area ·4277 square inch. Reduced diameter after fracture ·728 inch. Area ·4162 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	22009	....	....	·0018	....	Specimen of best cast steel for hot and cold sates-cups, shear blades, and boiler - maker's steel.
2	25369	....	....	·0025		
3	28729	....	....	·0050		
4	31849	....	....	·0081		
5	33439	....	....	·0093		
6	35014	....	....	·0118		
7	36664	....	....	·0156		
8	39784	....	....	·0193		
9	42904	....	....	·0225		
10	44464	....	....	·0237		
11	46054	....	....	·0268		
12	47764	....	....	·0298		
13	49549	115849	51·71	....	·0212	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 115,849 lbs., or 51·71 tons; and the corresponding elongation (l_1) per unit of length is ·0298. By formula (13).—The work (u) expended in producing rupture = 1726.

Exp. XXIII.—Bar of Steel from Messrs. Osborn & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "O 4." Diameter of specimen ·73 inch. Area ·4185 square inch. Reduced diameter after fracture ·725 inch. Area ·4128 square inch.

1	25369	....	....	·0037	....	Specimen of best cast steel for taps and dies.
2	27049	....	....	·0050		
3	28729	....	....	·0062		
4	30304	....	....	·0075		
5	31849	....	....	·0100		
6	33439	....	....	·0118		
7	35014	....	....	·0131		
8	36664	....	....	·0143		
9	38224	....	....	·0168		
10	39784	....	....	·0181		
11	41344	98790	44·10	....	·0168	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 98,790 lbs., or 44·10 tons; and the corresponding elongation (l_1) per unit of length is ·0181. By formula (13).—The work (u) expended in producing rupture = 894.

Exp. XXIV.—Bar of Steel from Messrs. Osborn & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "O 5." Diameter of specimen ·714 inch. Area ·4312 square inch. Reduced diameter after fracture ·72 inch. Area ·4071 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	28729	....	....	·0125	....	Specimen of toughened cast steel for shafts, piston-rods, and machinery purposes.
2	31849	....	....	·0168		
3	33439	....	....	·0200		
4	35014	....	....	·0231		
5	38224	....	....	·0312		
6	41344	....	....	·0431		
7	44464	103116	46·03	....	·0525	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 103,116 lbs., or 46·03 tons; and the corresponding elongation (l_1) per unit of length is ·0431. By formula (13).—The work (u) expended in producing rupture = 2222.

Exp. XXV.—Bar of Steel from Messrs. Osborn & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "O 6." Diameter of specimen ·744 inch. Area ·4347 square inch. Reduced diameter after fracture ·734 inch. Area ·4231 square inch.

1	22009	....	....	·0031	....	Specimen of best double shear steel.
2	25369	....	....	·0062		
3	28729	....	....	·0125		
4	30304	....	....	·0143		
5	31849	....	....	·0168		
6	33439	....	....	·0187		
7	35014	....	....	·0206		
8	36664	....	....	·0243		
9	38224	87931	39·25	.....	·0243	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 87,931 lbs., or 39·25 tons; and the corresponding elongation (l_1) per unit of length is ·0243. By formula (13).—The work (u) expended in producing rupture = 1068.

EXP. XXVI.—Bar of Steel from Messrs. Osborn & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "O 7." Diameter of specimen ·738 inch. Area ·4277 square inch. Reduced diameter after fracture ·736 inch. Area ·4254 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	28729	....	....	·0037	....	Specimen of extra best cast steel for turning-tools, cast steel wheel axles, &c.
2	31849	....	....	·0037		
3	35014	....	....	·0037		
4	36664	85724	38·26	....	·0043	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 85,724 lbs., or 38·26 tons; and the corresponding elongation (l_1) per unit of length is ·0037. By formula (13).—The work (u) expended in producing rupture = 158.

EXP. XXVII.—Bar of Steel from Messrs. Osborn & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "O 8." Diameter of bar ·738 inch. Area ·4277 square inch. Reduced diameter after fracture ·596 inch. Area ·2789 square inch.

1	28729	....	....	·0131	....	Specimen of cast steel for boiler-plates.
2	31849	....	....	·0162		
3	35014	....	....	·0231		
4	38224	....	....	·0312		
5	41344	....	....	·0456		
6	44464	....	....	·0625		
7	46054	....	....	·1062		
8	47764	111676	49·85	....	·1350	Broke in centre.

Results.—Here the breaking strain (P_1) per square inch of section is 111,676 lbs., or 49·85 tons; and the corresponding elongation (l_1) per unit of length is ·1062. By formula (13).—The work (u) expended in producing rupture = 5930.

EXP. XXVIII.—Bar of Steel from Messrs. Bessemer & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "BS1." Diameter of specimen ·728 inch. Area ·4162 square inch. Reduced diameter after fracture ·719 inch. Area ·406 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	18649	....	....	....	....	Bar of hard Bessemer steel.
2	25369	....	....	·0018		
3	28729	....	....	·0068		
4	30304	....	....	·0081		
5	31849	....	....	·0093		
6	35014	....	....	·0131		
7	38224	....	....	·0168		
8	41344	....	....	·0187		
9	42904	103085	46·02	....	·0187	Broke in two places.

Results.—Here the breaking strain (P_1) per square inch of section is 103,085 lbs., or 46·02 tons; and the corresponding elongation (l_1) per unit of length is ·0187. By formula (13).—The work (u) expended in producing rupture = 963.

EXP. XXIX.—Bar of Steel from Messrs. Bessemer & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "BS2." Diameter of specimen ·743 inch. Area ·4335 square inch. Reduced diameter after fracture ·531 inch. Area ·2214 square inch.

1	18649	....	....	·0012	....	Specimen of milder Bessemer steel than No. 1.
2	22009	....	....	·0017		
3	25369	....	....	·0237		
4	27049	....	....	·0300		
5	28729	....	....	·0332		
6	30304	....	....	·0362		
7	31849	....	....	·0462		
8	33439	....	....	·0600		
9	35014	....	....	·0818		
10	36664	....	....	·1093		
11	38224	88175	39·36	....	·2000	Broke near centre.

Results.—Here the breaking strain (P_1) per square inch of section is 88,175 lbs., or 39·36 tons; and the corresponding elongation (l_1) per unit of length is ·1093. By formula (13).—The work (u) expended in producing rupture = 4818.

Exp. XXX.—Bar of Steel from Messrs. Bessemer & Co., Sheffield. Elongations taken on 8 inches length. Mark on bar, "B S 3." Diameter of specimen ·736 inch. Area ·4254 square inch. Reduced diameter after fracture ·486 inch. Area ·1885 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length. Elongation.	Per unit of length. Permanent set.	Remarks.
	lbs.	lbs.	tons.			
1	22009	....	....	·0025	....	Specimen of soft Bessemer steel.
2	25369	....	....	·0293		
3	27049	....	....	·0418		
4	28729	....	....	·0593		
5	30304	....	....	·0718		
6	31849	....	....	·0981		
7	33439	78606	35·09	....	·1912	Broke in centre.

Results.—Here the breaking strain (P_1) per square inch of section is 78,606 lbs., or 35·09 tons; and the corresponding elongation (l_1) per unit of length is ·0981. By formula (13).—The work (u) expended in producing rupture=3855.

Exp. XXXI.—Bar of Steel from Mr. Sanderson, Sharrow Vale Works. Elongations taken on 8 inches length. Mark on bar, "S 1." Diameter of specimen ·697 inch. Area ·3815 square inch. Reduced diameter after fracture ·694 inch. Area ·3782 square inch.

1	22009	....	....	·0050		Specimen of bar of cast steel, from K. B., a Russian iron, suitable for welding.
2	25369	....	....	·0087		
3	28729	....	....	·0162		
4	30304	....	....	·0187		
5	31849	83484	37·26	....	·0225	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 83,484 lbs., or 37·26 tons; and the corresponding elongation (l_1) per unit of length is ·0187. By formula (13).—The work (u) expended in producing rupture=780.

Exp. XXXII.—Bar of Steel from Mr. Sanderson, Sharrow Vale Works. Elongations taken on 8 inches length. Mark on bar, "S 2." Diameter of specimen ·737 inch. Area ·4266 square inch. Reduced diameter after fracture ·723 inch. Area ·4105 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	22009	....	....	·0018	....	Specimen of double shear steel, from GL, a Swedish iron.
2	25369	....	....	·0050		
3	27049	....	....	·0075		
4	28729	....	....	·0093		
5	31849	....	....	·0100		
6	33439	....	....	·0131		
7	36664	....	....	·0875		
8	39784	....	....	·0231		
9	41344	....	....	·0256		
10	42904	....	....	·0293		
11	44464	....	....	·0318		Bore this weight 15 seconds, and then broke in neck.
12	46054	107940	48·18	....	·0331	

Results.—Here the breaking strain (P_1) per square inch of section is 107,940 lbs., or 48·18 tons; and the corresponding elongation (l_1) per unit of length is ·0318. By formula (13).—The work (u) expended in producing rupture=1716.

Exp. XXXIII.—Bar of Steel from Mr. Sanderson, Sharrow Vale Works. Elongations taken on 8 inches length. Mark on bar, "S 3." Diameter of specimen ·714 inch. Area ·4003 square inch. Reduced diameter after fracture ·693 inch. Area ·3771 square inch.

1	22009	....	....	·0037	....	Specimen of single shear steel from GL, a Swedish iron.
2	25369	....	....	·0100		
3	28729	....	....	·0156		
4	31849	....	....	·0212		
5	35014	....	....	·0225		
6	38224	....	....	·0250		
7	41344	....	....	·0275		
8	42904	107182	47·84	....	·0281	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 107,182 lbs., or 47·84 tons; and the corresponding elongation (l_1) per unit of length is ·0275. By formula (13).—The work (u) expended in producing rupture =1473.

EXP. XXXIV.—Bar of Steel from Mr. Sanderson, Sharrow Vale Works. Elongations taken on 8 inches length. Mark on bar, "S 4." Diameter of specimen ·744 inch. Area ·4374 square inch. Reduced diameter after fracture ·737 inch. Area ·4266 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	22009	....	....	·0031	....	Bar of faggot steel drawn from GL bar steel, simply welded to make it sound.
2	25369	....	....	·0043		
3	27049	....	....	·0081		
4	28729	....	....	·0087		
5	30304	....	....	·0125		
6	31849	....	....	·0137		
7	32689	75199	33·57	....	·0125	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 75,199 lbs., or 33·57 tons; and the corresponding elongation (l_1) per unit of length is ·0137. By formula (13).—The work (u) expended in producing rupture = 515.

EXP. XXXV.—Bar of Steel from Mr. Sanderson, Sharrow Vale Works. Elongations taken on 8 inches length. Mark on bar, "S 5." Diameter of specimen ·738 inch. Area ·4277 square inch. Reduced diameter after fracture ·723 inch. Area ·4105 square inch.

1	25369	....	....	·0037	....	Specimen of drawn bar from GL steel not welded.
2	27049	....	....	·0050		
3	28729	....	....	·0087		
4	30304	....	....	·0156		
5	31879	....	....	·0162		
6	33439	....	....	·0187		
7	35014	....	....	·0212		
8	36664	....	....	·0243		
9	39784	....	....	·0262		
10	41344	....	....			
11	42904	....	....			
12	44464	103960	46·41	....	·0343	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 103,960 lbs., or 46·41 tons; and the corresponding elongation (l_1) per unit of length is ·0262. By formula (13).—The work (u) expended in producing rupture = 1782.

Exp. XXXVI.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Elongations taken on 8 inches length. Mark on bar, "A." Diameter of specimen ·725 inch. Area ·4128 square inch. Reduced diameter after fracture ·709 inch. Area ·3948 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	22009	....	....	·0025	....	Specimen of steel employed in the manufacture of cups.
2	25369	....	....	·0043		
3	28729	....	....	·0100		
4	31849	....	....	·0143		
5	35014	....	....	·0187		
6	38224	....	....	·0250		
7	39784	....	....	·0312		
8	41344	100155	44·71	....	·0275	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 100,155 lbs., or 44·71 tons; and the corresponding elongation (l_1) per unit of length is ·0312. By formula (13).—The work (u) expended in producing rupture = 1562.

Exp. XXXVII.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Elongations taken on 8 inches length. Mark on bar, "B." Diameter of specimen ·745 inch. Area ·4359 square inch. Reduced diameter after fracture ·74 inch. Area ·43 square inch.

1	22009	....	....	·0018	....	Specimen of steel used in the manufacture of drills.
2	25369	....	....	·0018		
3	28729	....	....	·0018		
4	31849	....	....	·0031		
5	35014	....	....	·0106		
6	36604	....	....	·0106		
7	38164	87552	39·08	....	·0106	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 87,552 lbs., or 39·08 tons; and the corresponding elongation (l_1) per unit of length is ·0106. By formula (13).—The work (u) expended in producing rupture = 464.

EXP. XXXVIII.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Elongations taken on 8 inches length. Mark on bar, "C." Diameter of specimen ·743 inch. Area ·4335 square inch. Reduced diameter after fracture ·74 inch. Area ·43 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	22009	....	....	·0031	....	Specimen of steel used in the manufacture of cutters.
2	25369	....	....	·0031		
3	28729	....	....	·0031		
4	30304	....	....	·0031		
5	31849	....	....	·0037		
6	33439	....	....	·0106		
7	35014	....	....	·0137		
8	36664	....	....	·0150		
9	38224	....	....	·0162		
10	39784	....	....	·0181		
11	41344	95372	42·57	....	·0137	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 95,372 lbs., or 42·57 tons; and the corresponding elongation (l_1) per unit of length is ·0181. By formula (13).—The work (u) expended in producing rupture = 863.

EXP. XXXIX.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Elongations taken on 8 inches length. Mark on bar, "D." Diameter of specimen ·719 inch. Area ·4060 square inch. Reduced diameter after fracture ·717 inch. Area ·4037 square inch.

1	22009	....	....	....	....	Specimen of steel used in the construction of turning-tools.
2	25369	....	....	·0006		
3	28729	....	....	·0018		
4	31849	80273	35·02	....	·0012	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 80,273 lbs., or 35·02 tons; and the corresponding elongation (l_1) per unit of length is ·0018. By formula (13).—The work (u) expended in producing rupture = 72.

Exp. XL.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Elongations taken on 8 inches length. Mark on bar, "E." Diameter of specimen ·743 inch. Area ·4335 square inch. Reduced diameter after fracture ·737 inch. Area ·4266 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	22009	....	....	·0006	....	Specimen of steel used in the manufacture of machinery.
2	25369	....	....	·0018		
3	28729	....	....	·0031		
4	31849	....	....	·0062		
5	35014	....	....	·0093		
6	36664	....	....	·0106		
7	39784	....	....	·0143		
8	42904	....	....	·0181		
9	44614	102915	45·94	....	·0143	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 102,915 lbs., or 45·94 tons; and the corresponding elongation (l_1) per unit of length is ·0181. By formula (13).—The work (u) expended in producing rupture = 929.

Exp. XLI.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Elongations taken on 8 inches length. Mark on bar, "F." Diameter of specimen ·743 inch. Area ·4335 square inch. Reduced diameter after fracture ·738 inch. Area ·4277 square inch.

1	22009	....	....	·0025	....	Specimen of steel used in the manufacture of punches.
2	25369	....	....	·0050		
3	28729	....	....	·0081		
4	31849	....	....	·0100		
5	35014	....	....	·0125		
6	38224	....	....	·0181		
7	41344	....	....	·0206		
8	44464	102567	45·79	....	·0162	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 102,567 lbs., or 45·79 tons; and the corresponding elongation (l_1) per unit of length is ·0206. By formula (13).—The work (u) expended in producing rupture = 1056.

Exp. XLII.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Elongations taken on 8 inches length. Mark on bar, "G." Diameter of specimen ·743 inch. Area ·4335 square inch. Reduced diameter after fracture ·729 inch. Area ·4173 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	22009	....	....	·0018	....	Specimen of steel used in the manufacture of Mint dies.
2	25369	....	....	·0018		
3	28729	....	....	·0050		
4	31849	....	....	·0081		
5	35014	....	....	·0112		
6	38224	....	....	·0150		
7	41344	....	....	·0187		
8	42904	....	....	·0243		
9	46054	106237	47·42	....	·0287	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 106,237 lbs., or 47·42 tons; and the corresponding elongation (l_1) per unit of length is ·0243. By formula (13).—The work (u) expended in producing rupture = 1290.

Exp. XLIII.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Elongations taken on 8 inches length. Mark on bar, "H." Diameter of specimen ·746 inch. Area ·4370 square inch. Reduced diameter after fracture ·741 inch. Area ·43 square inch.

1	25369	....	....	·0025	...	Specimen of steel used in the manufacture of dies.
2	28729	....	....	·0031		
3	31849	....	....	·0093		
4	35014	....	....	·0131		
5	38224	87471	39·04	....	·0087	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 87,471 lbs., or 39·04 tons; and the corresponding elongation (l_1) per unit of length is ·0131. By formula (13).—The work (u) expended in producing rupture = 572.

Exp. XLIV.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Elongations taken on 8 inches length. Mark on bar, "I." Diameter of specimen ·733 inch. Area ·4219 square inch. Reduced diameter after fracture ·725 inch. Area ·4128 square inch.

No. of Exp.	Weight laid on.	Breaking strain per square inch of section.		Per unit of length.		Remarks.
				Elongation.	Permanent set.	
	lbs.	lbs.	tons.			
1	25369	....	....	·0031	....	Specimen of double shear steel.
2	28729	....	....	·0056		
3	31849	....	....	·0087		
4	33439	....	....	·0106		
5	35014	....	....	·0118		
6	36664	....	....	·0143		
7	38224	....	....	·0169		
8	39784	....	....	·0193		
9	41344	97994	43·74	....	·0187	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 97,994 lbs., or 43·74 tons; and the corresponding elongation (l_1) per unit of length is ·0193. By formula (13).—The work (u) expended in producing rupture = 945.

Exp. XLV.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Elongations taken on 8 inches length. Mark on bar, "U." Diameter of specimen ·744 inch. Area ·4347 square inch. Reduced diameter after fracture ·74 inch. Area ·43 square inch.

1	22009	....	....	·0037	....	Specimen of double Shear steel.
2	25369	....	....	·0050		
3	28729	....	....	·0087		
4	31849	73266	32·70	....	·0081	Broke in neck.

Results.—Here the breaking strain (P_1) per square inch of section is 73,266 lbs., or 32·70 tons; and the corresponding elongation (l_1) per unit of length is ·0087. By formula (13).—The work (u) expended in producing rupture = 318.

Table II.—Summary of Results of the Experiments on Tensile Strain.

No. of Exp.	Manufacturers.	Mark on Bar.	Specific gravity of specimen.	Weight laid on, in lbs., producing rupture.	Breaking strain per square inch of section.		Corresponding elongation per unit of length or value, $l_1 = \frac{l}{L}$.	Value of u, or work producing rupture. By eq. (13).	Remarks.
					lbs.	tons.			
	Messrs. Brown and Co.								
1	Best cast steel from Russian and Swedish iron, for turning-tools	B 1	7·7902	31849	68404	30·53	·0056	191	Broke in neck.
2	Ditto, milder	B 2	7·7522	39784	91520	40·85	·0150	686	"
3	Cast steel from Swedish iron, for tools	B 3	7·7968	30371	106714	47·64	·0143	763	"
4	Ditto, milder, for chisels	B 4	7·7890	49564	116183	51·86	·0337	1957	"
5	Ditto, mild, for welding	B 5	7·8143	31916	110055	49·13	·0375	2063	"
6	Bessemer steel	B 6	7·7630	39764	91972	41·05	·0837	4522	"
7	Specimen of double shear steel from Swedish iron	B 7	7·7758	39799	92555	41·31	·0406	1878	"
8	Ditto, foreign bar, tilted direct	B 8	7·7271	22211	76474	34·27	·0968	3715	Broke 1 inch from the neck.
9	English tilted steel made from English and foreign pigs	B 9	7·7888	17171	59538	26·57	·0762	2268	Broke in centre.
	Messrs. Cammell and Co.								
10	Specimen of cast steel, termed "Diamond Steel"	1	....	31916	110055	49·13	·0177	974	Broke 2½ in. from the neck.
11	Do. steel, termed "Tool Steel"	2	7·8034	31871	109072	48·69	·0206	1123	Broke in neck.
12	Do. cast steel, termed "Chisel Steel"	3	....	35066	120398	53·75	·0281	1691	"
13	Do. do. termed "Double Shear Steel"	4	7·7915	41344	96665	43·15	·0250	1208	"
14	Bar of hard Bessemer steel	5	7·8240	38224	89121	39·78	·1437	6403	Broke near centre.
15	Do. soft do	6	7·8289	23891	81483	36·37	·1200	4888	"
	Messrs. Naylor, Vickers, and Co.								
16	Cast steel called "Axle Steel"	A	8·7025	25571	88665	39·58	·0625	2770	Broke in centre.
17	Do. do. "Tyre Steel"	T	7·7484	39784	91520	40·85	·0475	2173	Broke 2¾ in. from the neck.
18	Do. do. "Vickers's Cast Steel, Special"	S	7·9359	57374	134145	59·87	·0100	670	Broke in neck.
19	Do. do. "Naylor and Vickers's Cast Steel"	S 26	7·7927	35066	118066	52·70	·0287	1694	

	Messrs. Osborn and Co.								
20	Specimen of best tool, cast steel	O 1	....	43129	98942	44·17	·0156	771	Broke in neck.
21	Do. chisel do.	O 2	7·7769	51899	123686	55·21	·0318	1966	"
22	Bar of best cast steel for hot and cold sates-cup, shear blades, and boiler-maker's steel	O 3	7·7702	49549	115849	51·71	·0298	1726	"
23	Best cast steel for taps and dies	O 4	7·7502	41344	98790	44·10	·0181	894	"
24	Toughened cast steel for shafts, &c.	O 5	7·7814	44464	103116	46·03	·0431	2222	"
25	Specimen of best double shear steel	O 6	7·7970	38224	87931	39·25	·0243	1068	"
26	Extra best tool, cast steel	O 7	7·7604	36664	85724	38·26	·0037	158	"
27	Cast steel for boiler-plates	O 8	7·7949	47764	111676	49·85	·1062	5930	Broke in centre.
	Messrs. Bessemer and Co.								
28	Specimen of hard Bessemer steel	BS 1	7·7478	42904	103085	46·02	·0187	963	Broke in two places.
29	Do. milder quality	BS 2	7·8082	38224	88175	39·36	·1093	4818	Broke near centre.
30	Do. soft do.	BS 3	7·7618	33439	78606	35·09	·0981	3855	Broke in centre.
	Messrs. Sanderson Brothers.								
31	Bar of cast steel from Russian iron, suitable for welding	S 1	7·7750	31849	83484	37·26	·0187	780	Broke in neck.
32	Specimen of double shear steel	S 2	7·7303	46054	107940	48·18	·0318	1716	"
33	Do. single do.	S 3	7·7719	42904	107182	47·84	·0275	1473	"
34	Bar of faggot steel, simply welded	S 4	7·7795	32689	75199	33·57	·0137	515	"
35	Specimen of drawn bar, not welded	S 5	7·7251	44464	103960	46·41	....	1782	"
	Messrs. Turton and Sons.								
36	Steel intended for the manufacture of cups	A	7·7871	41344	100155	44·71	·0312	1562	Broke in neck.
37	Do. do. drills	B	7·7458	38164	87552	39·08	·0106	464	"
38	Do. do. cutters	C	7·7644	41344	95372	42·57	·0181	863	"
39	Do. do. turning-tools	D	7·7811	31849	80273	35·02	·0018	72	"
40	Do. do. machinery	E	7·7806	44614	102915	45·94	·0181	929	"
41	Do. do. punches	F	7·7634	44464	102567	45·79	·0206	1056	"
42	Do. do. mint dies	G	7·7641	46054	106237	47·42	·0243	1290	"
43	Do. do. dies	H	7·7949	38224	87471	39·04	·0131	572	"
44	Do. do. taps	I	7·8169	41344	97994	43·74	·0193	945	"
45	Specimen of double shear steel	U	7·7821	31849	73266	32·70	·0087	318	"

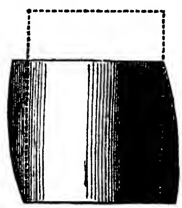
It will be observed from the above Summary of Results, that in the reduction of the experiments to the value of u, or work done in producing rupture, some of the specimens are as low as 72 when the metal is hard and brittle, and as high as 6403 (in Exp. 14) where the specimen is of ductile Bessemer steel. It required the utmost precision to determine with perfect accuracy the elongations of the harder specimens at the point of rupture; and although the elongations were magnified and carefully taken, they are nevertheless not to be relied upon where the value of u is under 300. It would have been more correct to have taken the elongations from bars three or four times the length; but this could not be accomplished from the same bars, as in most cases it was next to impossible to have them reduced to the required dimensions without heating the bars and drawing them out under the hammer. This process would have rendered them useless for comparison, which is not the case in the present experiments, where the rupture by tension is identical with that by compression, as they were cut from the same bars after having been submitted to a transverse strain. From this it will be seen that each bar has undergone without change the three separate tests of tensile, compressive, and transverse strain.

THIRD SERIES OF EXPERIMENTS.

COMPRESSION.

Exp. I.—Bar of Steel from Messrs. John Brown & Co., Sheffield. Mark on bar, "B 1."

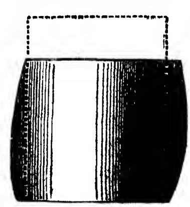
	Before experiment.		After experiment.
Height of specimen	1·004 inch.	....	·755 inch.
Diameter of specimen	·72 inch.	....	·774 inch.
Area of specimen	·40715 sq. in.	....	·47015 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·731	91951	41·049	·020	
2	44966	20·074	110440	49·303	·025	
3	52166	23·288	128124	57·198	·043	
4	58950	26·316	144786	64·637	·049	
5	66022	29·474	162156	72·391	·078	
6	73134	32·649	179772	80·233	·117	
7	80214	35·809	197023	87·952	·166	
8	88134	39·345	216465	96·636	·225	
9	91840	41·000	225568	100·700	·253	One very slight crack appeared.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·253. By formula (13).—The work (u) expended in producing rupture = 28533.

Exp. II.—Bar of Steel from Messrs. John Brown & Co., Sheffield. Mark on bar, "B 2."

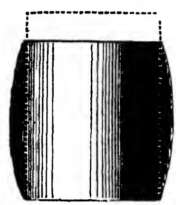
	Before experiment.		After experiment.
Height of specimen......	·980 inch.	....	·724 inch.
Diameter of specimen	·72 inch.	....	·785 inch.
Area of specimen........	·40715 sq. in.	....	·48398 sq. in.

1	37438	16·731	91951	41·049	·020	
2	44966	20·074	110440	49·303	·025	
3	52166	23·288	128124	57·198	·043	
4	58950	26·316	144786	64·637	·069	
5	66022	29·474	162156	72·391	·088	
6	73134	32·649	179772	80·233	·147	
7	80214	35·809	197023	87·952	·196	
8	88134	39·345	216465	96·636	·265	
9	91840	41·000	225568	100·700	·263	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·263. By formula (13).—The work (u) expended in producing rupture = 29592.

Exp. III.—Bar of Steel from Messrs. John Brown & Co. Mark on bar, "B 3."

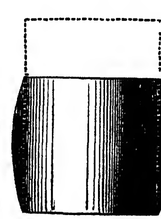
	Before experiment.		After experiment.
Height of specimen	1·002 inch.	....	·832 inch.
Diameter of specimen	·72 inch.	....	·748 inch.
Area of specimen	·40715 sq. in.	....	·43943 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·010	
2	44966	20·074	110440	49·303	·015	
3	52166	23·288	128124	57·198	·023	
4	58950	26·316	144786	64·637	·029	
5	66022	29·474	162516	72·391	·038	
6	73134	32·649	179722	80·233	·067	
7	80214	35·809	197023	87·952	·096	
8	88134	39·345	216465	96·636	·155	
9	91840	41·000	225568	100·700	·183	One very slight crack of outside skin.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding elongation (l_1) per unit of length is ·183. By formula (13).—The work (u) expended in producing rupture = 20591.

Exp. IV.—Bar of Steel from Messrs. John Brown & Co. Mark on bar, "B 4."

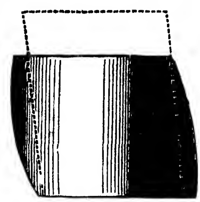
	Before experiment,		After experiment.
Height of specimen	1·01 inch.	....	·739 inch.
Diameter of specimen	·72 inch.	....	·781 inch.
Area of specimen	·40715 sq. in.	....	·47783 sq. in.

1	37438	16·713	91951	41·049	·030	
2	44966	20·074	110440	49·303	·035	
3	52166	23·288	128124	57·198	·053	
4	58950	26·316	144786	64·637	·079	
5	66022	29·474	162156	72·391	·108	
6	73134	32·649	179722	80·233	·157	
7	80214	35·809	197023	87·952	·206	
8	88134	39·345	216465	97·636	·255	
9	91840	41·000	225568	100·700	·293	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·293. By formula (13).—The work (u) expended in producing rupture =32968.

Exp. V.—Bar of Steel from Messrs. John Brown & Co. Mark on bar, "B 5."

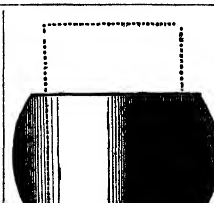
	Before experiment.		After experiment.
Height of specimen	·99 inch.	....	·743 inch.
Diameter of specimen	·72 inch.	....	·776 inch.
Area of specimen............	·40715 sq. in.	....	·47299 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·010	
2	44966	20·074	110440	49·303	·015	
3	52166	23·288	128124	57·198	·023	
4	58950	26·316	144786	64·637	·039	
5	66022	29·474	162156	72·391	·068	
6	73134	32·649	179722	80·233	·107	
7	80214	35·809	197023	87·952	·166	
8	88134	39·345	216465	96·636	·215	
9	91840	41·000	225568	100·700	·243	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·243. By formula (13).—The work (u) expended in producing rupture=27342.

Exp. VI.—Bar of Steel from Messrs. John Brown & Co. Mark on bar, "B 6."

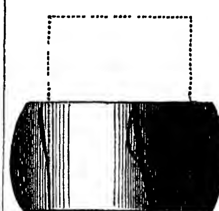
	Before experiment.		After experiment.
Height of specimen	·987 inch.	....	·592 inch.
Diameter of specimen	·72 inch.	....	·84 inch.
Area of specimen	·40715 sq. in.	....	·55417 sq. in.

1	37438	16·713	91951	41·049	·050	
2	44966	20·074	110440	49·303	·075	
3	52166	23·288	128124	57·198	·123	
4	58950	26·316	144786	64·637	·179	
5	66022	29·474	162156	72·391	·238	
6	73134	32·649	179722	80·233	·297	
7	80214	35·809	197023	87·952	·346	
8	88134	39·345	216465	96·636	·385	
9	91840	41·000	225568	100·700	·403	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·403. By formula (13).—The work (u) expended in producing rupture=45345.

Exp. VII.—Bar of Steel from Messrs. John Brown & Co. Mark on bar, "B 7."

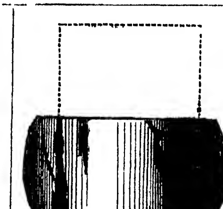
	Before experiment.		After experiment.
Height of specimen..........	·401 inch.	....	·559 inch.
Diameter of specimen........	·72 inch.	....	·886 inch.
Area of specimen............	·40715 sq. in.	....	·61653 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·030	
2	44966	20·074	110440	49·303	·065	
3	52166	23·288	128124	57·198	·103	
4	58950	26·316	144786	64·637	·169	
5	66022	29·474	162156	72·391	·238	
6	73134	32·649	179722	80·233	·297	
7	80214	35·809	197023	87·952	·366	
8	88134	39·345	216465	96·636	·425	
9	91840	41·000	225568	100·700	·443	Three large cracks, with several smaller ones.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·443. By formula (13).—The work (u) expended in producing rupture=49846.

Exp. VIII.—Bar of Steel from Messrs. John Brown & Co. Mark on bar, "B 8."

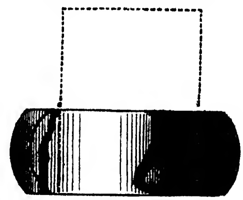
	Before experiment.		After experiment.
Height of specimen..........	·989 inch.	....	·497 inch.
Diameter of specimen........	·72 inch.	....	·886 inch.
Area of specimen............	·40715 sq. in.	....	·61653 sq. in.

1	37438	16·713	91951	41·049	·040	
2	44966	20·074	110440	49·303	·085	
3	52166	23·288	128124	57·198	·143	
4	58950	26·316	144786	64·637	·219	
5	66022	29·474	162156	72·391	·298	
6	73134	32·649	179722	80·233	·347	
7	80214	35·809	197023	87·952	·426	
8	88134	39·345	216465	96·636	·475	
9	91840	41·000	225568	100·700	·493	Much cracked.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·493. By formula (13).—The work (u) expended in producing rupture = 55472.

Exp. IX.—Bar of Steel from Messrs. John Brown & Co., Sheffield. Mark on bar, "B 9."

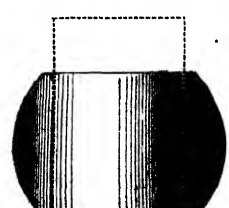
	Before experiment.		After experiment.
Height of specimen	·983 inch.	....	·430 inch.
Diameter of specimen	·72 inch.	....	·98 inch.
Area of specimen	·40715 sq. in.	....	·75429 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·150	
2	44966	20·074	110440	49·303	·215	Commenced to crack.
3	52166	23·288	128124	57·198	·273	
4	58950	26·316	144786	64·637	·359	
5	66022	29·474	162156	72·391	·418	
6	73134	32·649	179722	80·233	·457	
7	80214	35·809	197023	87·952	·486	Three large cracks.
8	88134	39·345	216465	96·636	·535	
9	91840	41·000	225568	100·700	·553	Much cracked.

Results—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·553. By formula (13).—The work (u) expended in producing rupture = 62223.

Exp. X.—Bar of Steel from Messrs. Cammell & Co., Sheffield. Mark on bar, "1."

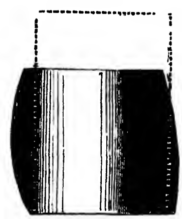
	Before experiment.		After experiment.
Height of specimen	·971 inch.	....	·749 inch.
Diameter of specimen	·72 inch.	....	·772 inch.
Area of specimen	·40715 sq. in.	....	·46808 sq. in.

1	37438	16·713	91951	41·049	·010	
2	44966	20·074	110440	49·303	·015	
3	52166	23·288	128124	57·198	·023	
4	58950	26·316	144786	64·637	·029	
5	66022	29·474	162156	72·391	·058	
6	73134	32·649	179722	80·233	·087	
7	80214	35·809	197023	87·952	·146	
8	88134	39·345	216465	96·636	·205	
9	91840	41·000	225568	100·700	·233	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·233. By formula (13).—The work (u) expended in producing rupture = 26217.

EXP. XI.—Bar of Steel from Messrs. Cammell & Co., Sheffield. Mark on bar, "2."

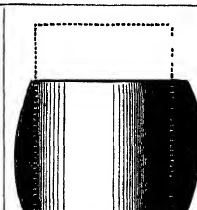
	Before experiment.		After experiment.
Height of specimen	1·005 inch.	....	·749 inch.
Diameter of specimen	·72 inch.	....	·772 inch.
Area of specimen..........	·40715 sq. in.	....	·46808 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·020	
2	44966	20·074	110440	49·303	·025	
3	52166	23·288	128124	57·198	·033	
4	58950	26·316	144786	64·637	·049	
5	66022	29·474	162156	72·391	·068	
6	73134	32·649	179722	80·233	·117	
7	80214	35·809	197023	87·952	·176	
8	88134	39·345	216465	96·636	·235	
9	91840	41·000	225568	100·700	·263	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·263. By formula (13).—The work (u) expended in producing rupture = 29592.

EXP. XII.—Bar of Steel from Messrs. Cammell & Co., Sheffield. Mark on bar, "3."

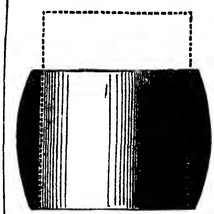
	Before experiment.		After experiment.
Height of specimen	1·00 inch.	....	·705 inch.
Diameter of specimen	·72 inch.	....	·79 inch.
Area of specimen..........	·40715 sq. in.	....	·49016 sq. in.

1	37438	16·713	91951	41·049	·020	
2	44966	20·074	110440	49·303	·035	
3	52166	23·288	128124	57·198	·053	
4	58950	26·316	144786	64·637	·089	
5	66022	29·474	162156	72·391	·138	
6	73134	32·649	179722	80·233	·187	
7	80214	35·809	197023	87·952	·236	
8	88134	39·345	216465	96·636	·285	
9	91840	41·000	225568	100·700	·313	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·313. By formula (13).—The work (u) expended in producing rupture = 35218.

Exp. XIII.—Bar of Steel from Messrs. Cammell & Co., Sheffield. Mark on bar, "4."

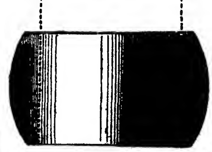
	Before experiment.		After experiment.
Height of specimen	1·001 inch.	....	·704 inch.
Diameter of specimen	·72 inch.	....	·80 inch.
Area of specimen	·40715 sq. in.	....	·50265 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·030	
2	44966	20·074	110440	49·303	·045	
3	52166	23·288	128124	57·198	·053	
4	58950	26·316	144786	64·637	·079	
5	66022	29·474	162156	72·391	·128	
6	73134	32·649	179722	80·233	·177	
7	80214	35·809	197023	87·952	·236	
8	88134	39·345	216465	96·636	·285	
9	91840	41·000	225568	100·700	·303	Very slight cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·303. By formula (13).—The work (u) expended in producing rupture =34171.

Exp. XIV.—Bar of Steel from Messrs. Cammell & Co., Sheffield. Mark on bar, "5."

	Before experiment.		After experiment.
Height of specimen............	·996 inch.	....	·579 inch.
Diameter of specimen..........	·72 inch.	....	·865 inch.
Area of specimen	·40715 sq. in.	....	·58765 sq. in.

1	37438	16·713	91951	41·049	·060	
2	44966	20·074	110440	49·303	·095	
3	52166	23·288	128124	57·198	·143	
4	58950	26·316	144786	64·637	·199	
5	66022	29·474	162156	72·391	·268	
6	73134	32·649	179722	80·233	·317	
7	80214	35·809	197023	87·952	·406	
8	88134	39·345	216465	96·636	·415	
9	91840	41·000	225568	100·700	·433	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·433. By formula (13).—The work (u) expended in producing rupture =48721.

Exp. XV.—Bar of Steel from Messrs. Cammell & Co., Sheffield. Mark on bar, "6."

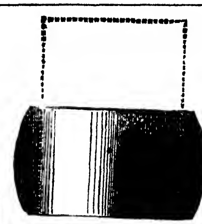
	Before experiment.		After experiment.
Height of specimen............	·997 inch.	....	·514 inch.
Diameter of specimen..........	·72 inch.	....	·891 inch.
Area of specimen	·40715 sq. in.	....	·63334 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·080	
2	44966	20·074	110440	49·303	·135	
3	52166	23·288	128124	57·198	·203	
4	58950	26·316	144786	64·637	·269	
5	66022	29·474	162156	72·391	·328	
6	73134	32·649	179722	80·233	·387	
7	80214	35·809	197023	87·952	·426	
8	88134	39·345	216465	96·636	·465	
9	91840	41·000	225568	100·700	·493	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·493. By formula (13).—The work (u) expended in producing rupture =55472.

Exp. XVI.—Bar of Steel from Messrs. Naylor, Vickers & Co. Mark on bar, "V. A."

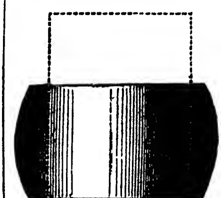
	Before experiment.		After experiment.
Height of specimen............	·983 inch.	....	·569 inch.
Diameter of specimen..........	·72 inch.	....	·865 inch.
Area of specimen	·40715 sq. in.	....	·58765 sq. in.

1	37438	16·713	91951	41·049	·050	
2	44966	20·074	110440	49·303	·075	
3	52166	23·288	128124	57·198	·123	
4	58950	26·316	144786	64·637	·179	
5	66022	29·474	162156	72·391	·248	
6	73134	32·649	179722	80·233	·307	
7	80214	35·809	197023	87·952	·356	
8	88134	39·345	216465	96·636	·395	
9	91840	41·000	225568	100·700	·423	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·423. By formula (13).—The work (u) expended in producing rupture =47596

Exp. XVII.—Bar of Steel from Messrs. Naylor, Vickers & Co., Sheffield. Mark on bar "V.T."

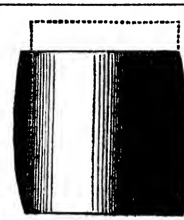
	Before experiment.		After experiment.
Height of specimen..........	·992 inch.	....	·605 inch.
Diameter of specimen........	·72 inch.	....	·840 inch.
Area of specimen	·40715 sq. in.	....	·55417 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Com-pression, in inches	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·050	
2	44966	20·074	110440	49·303	·075	
3	52166	23·288	128124	57·198	·113	
4	58950	26·316	144786	64·637	·169	
5	66022	29·474	162156	72·391	·228	
6	73134	32·649	179722	80·233	·257	
7	80214	35·809	197023	87·952	·326	
8	88134	39·345	216465	96·636	·365	
9	91840	41·000	225568	100·700	·388	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·388. By formula (13).—The work (u) expended in producing rupture = 43758.

Exp. XVIII.—Bar of Steel from Messrs. Naylor, Vickers & Co., Sheffield. Mark on bar "V.S."

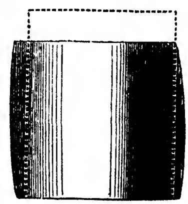
	Before experiment.		After experiment.
Height of specimen..........	·989 inch.	....	·847 inch.
Diameter of specimen........	·72 inch.	....	·742 inch.
Area of specimen	·40715 sq. in.	....	·43241 sq. in.

1	37438	16·713	91951	41·049	·010	
2	44966	20·074	110440	49·303	·015	
3	52166	23·288	128124	57·198	·023	
4	58950	26·316	144786	64·637	·029	
5	66022	29·474	162156	72·391	·038	
6	73134	32·649	179722	80·233	·047	
7	80214	35·809	197023	87·952	·076	
8	88134	39·345	216465	96·636	·125	
9	91840	41·000	225568	100·700	·153	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·153. By formula (13).—The work (u) expended in producing rupture = 17255.

Exp. XIX.—Bar of Steel from Messrs. Naylor, Vickers & Co., Sheffield. Mark on bar, "V.2."

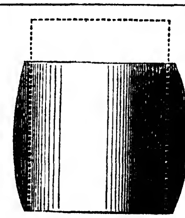
	Before experiment.		After experiment.
Height of specimen..........	·998 inch.	....	·818 inch.
Diameter of specimen........	·72 inch.	....	·76 inch.
Area of specimen	·40715 sq. in.	....	·45364 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section		Com-pression, in inches	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·010	
2	44966	20·074	110440	49·303	·015	
3	52166	23·288	128124	57·198	·023	
4	58950	26·316	144786	64·637	·029	
5	66022	29·474	162156	72·391	·038	
6	73134	32·649	179722	80·233	·057	
7	80214	35·809	197023	87·952	·096	
8	88134	39·345	216465	96·636	·155	
9	91840	41·000	225568	100·700	·183	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·183. By formula (13).—The work (u) expended in producing rupture = 20591.

Exp. XX.—Bar of Steel from Samuel Osborn, Esq., Sheffield. Mark on bar "O 1."

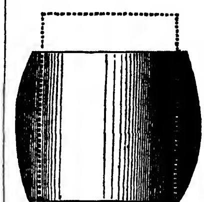
	Before experiment.		After experiment.
Height of specimen..........	·999 inch.	....	·796 inch.
Diameter of specimen........	·72 inch.	....	·764 inch.
Area of specimen	·40715 sq. in.	....	·45843 sq. in.

1	37438	16·713	91951	41·049	·020	
2	44966	20·074	110440	49·303	·025	
3	52166	23·288	128124	57·198	·033	
4	58950	26·316	144786	64·637	·039	
5	66022	29·474	162156	72·391	·058	
6	73134	32·649	179722	80·233	·077	
7	80214	35·809	197023	87·952	·126	
8	88134	39·345	216465	96·636	·185	
9	91840	41·000	225568	100·700	·203	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·203. By formula (13).—The work (u) expended in producing rupture = 22841.

Exp. XXI.—Bar of Steel from Samuel Osborn, Esq., Sheffield. Mark on bar, "O 2."

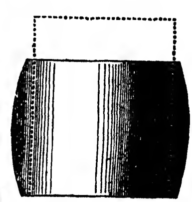
	Before experiment.		After experiment.
Height of specimen	·991 inch.	....	·766 inch.
Diameter of specimen	·72 inch.	....	·76 inch.
Area of specimen..........	·40715 sq. in.	....	·45364 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·030	
2	44966	20·074	110440	49·303	·035	
3	52166	23·288	128124	57·198	·043	
4	58950	26·316	144786	64·637	·069	
5	66022	29·474	162156	72·391	·088	
6	73134	32·649	179722	80·233	·127	
7	80214	35·809	197023	87·952	·176	
8	88134	39·345	216465	96·636	·225	
9	91840	41·000	225568	100·700	·243	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·243. By formula (13).—The work (u) expended in producing rupture =27342.

Exp. XXII.—Bar of Steel from Samuel Osborn, Esq., Sheffield. Mark on bar, "O 3."

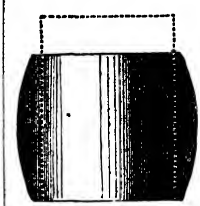
	Before experiment.		After experiment.
Height of specimen	·986 inch.	....	·748 inch.
Diameter of specimen	·72 inch.	....	·768 inch.
Area of specimen..........	·40715 sq. in.	....	·46324 sq. in.

1	37438	16·713	91951	41·049	·030	
2	44966	20·074	110440	49·303	·035	
3	52166	23·288	128124	57·198	·043	
4	58950	26·316	144786	64·637	·059	
5	66022	29·474	162156	72·391	·078	
6	73134	32·649	179722	80·233	·117	
7	80214	35·809	197023	87·952	·166	
8	88134	39·345	216465	96·636	·225	
9	91840	41·000	225568	100·700	·253	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·253. By formula (13).—The work (u) expended in producing rupture =28467.

Exp. XXIII.—Bar of Steel from Samuel Osborn, Esq., Sheffield. Mark on bar, "O 4."

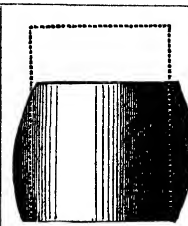
	Before experiment.		After experiment.
Height of specimen	·993 inch.	....	·743 inch.
Diameter of specimen	·72 inch.	....	·768 inch.
Area of specimen	·40715 sq. in.	....	·46324 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·020	
2	44966	20·074	110440	49·303	·035	
3	52166	23·288	128124	57·198	·043	
4	58950	26·316	144786	64·637	·059	
5	66022	29·474	162156	72·391	·078	
6	73134	32·649	179722	80·233	·117	
7	80214	35·809	197023	87·952	·186	
8	88134	39·345	216465	96·636	·235	
9	91840	41·000	225568	100·700	·263	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·263. By formula (13).—The work (u) expended in producing rupture =29592.

Exp. XXIV.—Bar of Steel from Samuel Osborn, Esq., Sheffield. Mark on bar, "O 5."

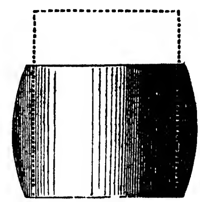
	Before experiment.		After experiment.
Height of specimen	1·01 inch.	....	·697 inch.
Diameter of specimen	·72 inch.	....	·79 inch.
Area of specimen	·40715 sq. in.	....	·49016 sq. in.

1	37438	16·713	91951	41·049	·030	
2	44966	20·074	110440	49·303	·045	
3	52166	23·288	128124	57·198	·083	
4	58950	26·316	144786	64·637	·109	
5	66022	29·474	162156	72·391	·158	
6	73134	32·649	179722	80·233	·197	
7	80214	35·809	197023	87·952	·266	
8	88134	39·345	216465	96·636	·295	
9	91840	41·000	225568	100·700	·323	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·323. By formula (13).—The work (u) expended in producing rupture =36344

Exp. XXV.—Bar of Steel from Samuel Osborn, Esq., Sheffield. Mark on bar, "O 6."

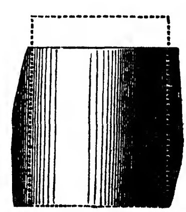
	Before experiment.		After experiment.
Height of specimen	·982 inch	....	·669 inch.
Diameter of specimen	·72 inch.	....	·80 inch.
Area of specimen	·40715 sq. in.	....	·50265 sq. in.

No. of Exp	Weight laid on specimen.		Weight laid on per square inch of section.		Compression in ins.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·030	
2	44966	20·074	110440	49·303	·045	
3	52166	23·288	128124	57·198	·073	
4	58950	26·316	144786	64·637	·099	
5	66022	29·474	162156	72·391	·148	
6	73134	32·640	179722	80·233	·207	
7	80214	35·809	197023	87·952	·266	
8	88134	39·345	216465	96·636	·305	
9	91840	41·000	225568	100·700	·323	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·323. By formula (13).—The work (u) expended in producing rupture =36344.

Exp. XXVI.—Bar of Steel from Samuel Osborn, Esq., Sheffield. Mark on bar, "O 7."

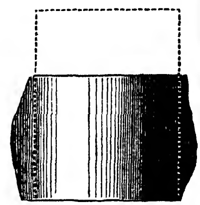
	Before experiment.		After experiment.
Height of specimen	1·011 inch.	....	·826 inch.
Diameter of specimen	·72 inch.	....	·748 inch.
Area of specimen	·40715 sq. in.	....	·43943 sq. in.

1	37438	16·713	91951	41·049	·010	
2	44966	20·074	110440	49·303	·015	
3	52166	23·288	128124	57·198	·023	
4	58950	26·316	144786	64·637	·029	
5	66022	29·474	162156	72·391	·038	
6	73134	32·649	179722	80·233	·077	
7	80214	35·809	197023	87·952	·106	
8	88134	39·345	216465	96·636	·165	
9	91840	41·000	225568	100·700	·193	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·193. By formula (13).—The work (u) expended in producing rupture=21716.

Exp. XXVII.—Bar of Steel from Samuel Osborn, Esq., Sheffield. Mark on bar, "O 8."

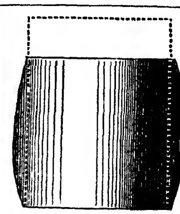
	Before experiment.		After experiment.
Height of specimen..........	·984 inch.	....	·652 inch.
Diameter of specimen........	·72 inch.	....	·812 inch.
Area of specimen	·40715 sq. in.	....	·51784 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in ins.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·030	
2	44966	20·074	110440	49·303	·035	
3	52166	23·288	128124	57·198	·063	
4	58950	26·316	144786	64·637	·099	
5	66022	29·474	162156	72·391	·158	
6	73134	32·649	179722	80·233	·217	
7	80214	35·809	197023	87·952	·266	
8	88134	39·345	216465	96·636	·315	
9	91840	41·000	225568	100·700	·333	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compession (l_1) per unit of length is ·333. By formula (13).—The work (u) expended in producing rupture =37469.

Exp. XXVIII.—Bar of Steel from Messrs. Bessemer and Co., Sheffield. Mark on bar, "B S 1."

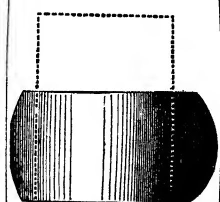
	Before experiment.		After experiment.
Height of specimen..........	·993 inch.	....	·773 inch.
Diameter of specimen........	·72 inch.	....	·764 inch.
Area of specimen	·40715 sq. in.	....	·45843 sq. in.

1	37438	16·713	91951	41·049	·030	
2	44966	20·074	110440	49·303	·035	
3	52166	23·288	128124	57·198	·043	
4	58950	26·316	144786	64·637	·049	
5	66022	29·474	162156	72·391	·068	
6	73134	32·649	179722	80·233	·097	
7	80214	35·809	197023	87·952	·146	
8	88134	39·345	216465	96·636	·195	
9	91840	41·000	225568	100·700	·223	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·223. By formula (13).—The work (u) expended in producing rupture =25092.

Exp. XXIX.—Bar of Steel from Messrs. Bessemer & Co., Sheffield. Mark on bar, "B S 2."

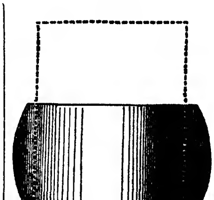
	Before experiment.		After experiment.
Height of specimen	1·01 inch.	....	·572 inch.
Diameter of specimen	·72 inch.	....	·856 inch.
Area of specimen........	·40715 sq. in.	....	·57549 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·060	
2	44966	20·074	110440	49·303	·095	
3	52166	23·288	128124	57·198	·143	
4	56950	26·316	144786	64·637	·219	
5	66022	29·474	162156	72·391	·278	
6	73134	32·649	179722	80·233	·337	
7	80214	35·809	197023	87·952	·386	
8	88134	39·345	216465	96·636	·425	
9	91840	41·000	225568	100·700	·443	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·443. By formula (13).—The work (u) expended in producing rupture = 49846.

Exp. XXX.—Bar of Steel from Messrs. Bessemer & Co., Sheffield. Mark on bar, "B S 3."

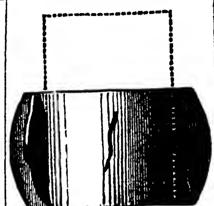
	Before experiment.		After experiment.
Height of specimen	1·002 inch.	....	·532 inch.
Diameter of specimen	·72 inch.	....	·894 inch.
Area of specimen........	·40715 sq. in.	....	·62771 sq. in.

1	37438	16·713	91951	41·049	·080	
2	44966	20·074	110440	49·303	·125	
3	52166	23·288	128124	57·198	·183	
4	56950	26·316	144786	64·637	·249	
5	66022	29·474	162156	72·391	·318	
6	73134	32·649	179722	80·233	·367	
7	80214	35·809	197023	87·952	·416	
8	88134	39·345	216465	96·636	·445	
9	91840	41·000	225568	100·700	·473	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·473. By formula (13).—The work (u) expended in producing rupture = 53222.

Exp. XXXI.—Bar of Steel from Messrs. Sanderson & Co., Sheffield. Mark on bar, "S. 1."

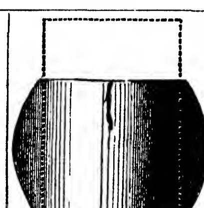
	Before experiment.		After experiment.
Height of specimen	·98 inch.	....	·576 inch.
Diameter of specimen	·72 inch.	....	·850 inch.
Area of specimen........	·40715 sq. in.	....	·56745 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches.	Remarks.
	lbs.	tons	lbs.	tons.		
1	37438	16·713	91951	41·049	·030	
2	44966	20·074	110440	49·303	·045	
3	52166	23·288	128124	57·198	·073	
4	58950	26·316	144786	64·637	·139	
5	66022	29·474	162156	72·391	·198	
6	73134	32·649	179722	80·233	·257	
7	80214	35·809	197023	87·952	·316	
8	88134	39 345	216465	96·636	·375	Two large cracks
9	91840	41·000	225568	100·700	·398	and a small one.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·398. By formula (13).—The work (u) expended in producing rupture = 44783.

Exp. XXXII.—Bar of Steel from Messrs. Sanderson & Co., Sheffield. Mark on bar, "S. 2."

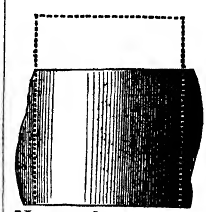
	Before experiment.		After experiment.
Height of specimen	·992 inch.	....	·698 inch.
Diameter of specimen	·72 inch.	....	·785 inch.
Area of specimen........	·40715 sq. in.	....	·48398 sq. in.

1	37438	16·713	91951	41·049	·030	
2	44966	20·074	110440	49·303	·035	
3	52166	23·288	128124	57·198	·053	
4	58950	26·316	144786	64·637	·079	
5	66022	29·474	162156	72·391	·118	
6	73134	32·649	179722	80·233	·177	
7	80214	35·809	197023	87·952	·236	
8	88134	39·345	216465	96·636	·275	
9	91840	41·000	225568	100·700	·303	Very slight crack.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·303. By formula (13).—The work (u) expended in producing rupture = 34093.

Exp. XXXIII.—Bar of Steel from Messrs. Sanderson & Co., Sheffield. Mark on bar, "S 3."

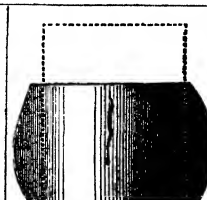
	Before experiment.		After experiment.
Height of specimen	·99 inch.	....	·710 inch.
Diameter of specimen	·72 inch.	....	·768 inch.
Area of specimen	·40715 sq. in.	....	·46324 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section		Compression, in inches.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·020	
2	44966	20·074	110440	49·303	·025	
3	52166	23·288	128124	57·198	·033	
4	58950	26·316	144786	64·637	·049	
5	66022	29·474	162156	72·391	·078	
6	73134	32·649	179722	80·233	·147	
7	80214	35·809	197023	87·952	·206	
8	88134	39·345	216465	96·636	·255	
9	91840	41·000	225568	100·700	·283	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·283. By formula (13).—The work (u) expended in producing rupture =31843.

Exp. XXXIV.—Bar of Steel from Messrs. Sanderson & Co., Sheffield. Mark on bar, "S 4."

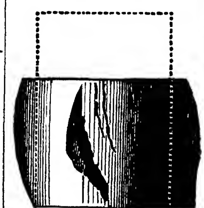
	Before experiment.		After experiment.
Height of specimen	·977 inch.	....	·658 inch.
Diameter of specimen	·72 inch.	....	·794 inch.
Area of specimen	·40715 sq. in.	....	·49514 sq. in.

1	37438	16·713	91951	41·049	·030	
2	44966	20·074	110440	49·303	·035	
3	52166	23·288	128124	57·198	·053	
4	58950	26·316	144786	64·637	·079	
5	66022	29·474	162156	72·391	·128	
6	73134	32·649	179722	80·233	·187	
7	80214	35·809	197023	87·952	·246	
8	88134	39·345	216465	96·636	·295	
9	91840	41·000	225568	100·700	·323	Several slight cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·323. By formula (13).—The work (u) expended in producing rupture =36344.

Exp. XXXV.—Bar of Steel from Messrs. Sanderson & Co., Sheffield. Mark on bar, "S 5."

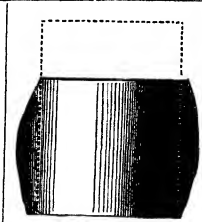
	Before experiment.		After experiment.
Height of specimen	1·01 inch.	....	·678 inch.
Diameter of specimen	·72 inch.	....	·790 inch.
Area of specimen	·40715 sq. in.	....	·49016 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·030	
2	44966	20·074	110440	49·303	·045	
3	52166	23·288	128124	57·198	·063	
4	58950	26·316	144786	64·637	·079	
5	66022	29·474	162156	72·391	·138	
6	73134	32·649	179722	80·233	·187	Commenced to
7	80214	35·809	197023	87·952	·246	crack.
8	88134	39·345	216465	96·636	·305	
9	91840	41·000	225568	100·700	·333	Cracks widened.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·333. By formula (13).—The work (u) expended in producing rupture =37469.

Exp. XXXVI.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Mark on bar, "A."

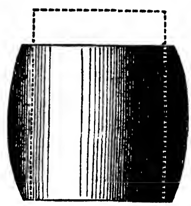
	Before experiment.		After experiment.
Height of specimen	·988 inch.	....	·71 inch.
Diameter of specimen	·72 inch.	....	·781 inch.
Area of specimen	·40715 inch.	....	·47783 sq. in.

1	37438	16·713	91951	41·049	·020	
2	44966	20·074	110440	49·303	·035	
3	52166	23·288	128124	57·198	·043	
4	58950	26·316	144786	64·637	·069	
5	66022	29·474	162156	72·391	·108	
6	73134	32·649	179722	80·233	·157	
7	80214	35·809	197023	87·952	·206	
8	88134	39·345	216465	96·636	·265	
9	91840	41·000	225568	100·700	·283	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·283. By formula (13).—The work (u) expended in producing rupture =31843.

Exp. XXXVII.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Mark on bar, "B."

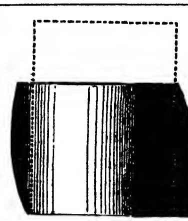
	Before experiment.		After experiment.
Height of specimen..........	·986 inch.	....	·804 inch.
Diameter of specimen........	·72 inch.	....	·748 inch.
Area of specimen	·40715 sq. in.	....	·43943 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·020	
2	44966	20·074	110440	49·303	·025	
3	52166	23·288	128124	57·198	·033	
4	58950	26·316	144786	64·637	·039	
5	66022	29·474	162156	72·391	·048	
6	73134	32·649	179722	80·233	·077	
7	80214	35·809	197023	87·952	·116	
8	88134	39·345	216465	96·636	·175	
9	91840	41·000	225568	100·700	·193	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·193. By formula (13).—The work (u) expended in producing rupture =21716.

Exp. XXXVIII.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Mark on bar, "C."

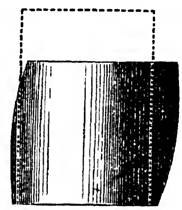
	Before experiment.		After experiment.
Height of specimen..........	·96 inch.	....	·716 inch.
Diameter of specimen........	·72 inch.	....	·781 inch.
Area of specimen	·40715 sq. in.	....	·47783 sq. in.

1	37438	16·713	91951	41·049	·030	
2	44966	20·074	110440	49·303	·035	
3	52166	23·288	128124	57·198	·043	
4	58950	26·316	144786	64·637	·049	
5	66022	29·474	162156	72·391	·078	
6	73134	32·649	179722	80·233	·127	
7	80214	35·809	197023	87·952	·166	
8	88134	39·345	216465	96·636	·225	
9	91840	41·000	225568	100·700	·243	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·243. By formula (13).—The work (u) expended in producing rupture =27342.

Exp. XXXIX.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Mark on bar, "D."

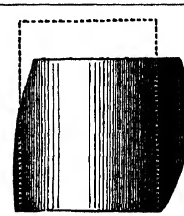
	Before experiment.		After experiment.
Height of specimen..........	·982 inch.	....	·751 inch.
Diameter of specimen........	·72 inch.	....	·774 inch.
Area of specimen	·40715 sq. in.	....	·47051 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·030	
2	44966	20·074	110440	49·303	·035	
3	52166	23·288	128124	57·198	·043	
4	58950	26·316	144786	64·637	·059	
5	66022	29·474	162156	72·391	·078	
6	73134	32·649	179722	80·233	·117	
7	80214	35·809	197023	87·952	·186	
8	88134	39·345	216465	96·636	·235	
9	91840	41·000	225568	100·700	·263	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·263. By formula (13).—The work (u) expended in producing rupture =29592.

Exp. XL.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Mark on bar, "E."

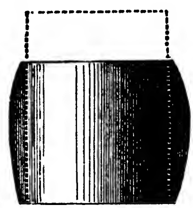
	Before experiment.		After experiment.
Height of specimen..........	1·00 inch.	....	·77 inch.
Diameter of specimen........	·72 inch.	....	·76 inch.
Area of specimen	·40715 sq. in.	....	·45364 sq. in.

1	37438	16·713	91951	41·049	·020	
2	44966	20·074	110440	49·303	·025	
3	52166	23·288	128124	57·198	·033	
4	58950	26·316	144786	64·637	·049	
5	66022	29·474	162156	72·391	·068	
6	73134	32·649	179722	80·233	·107	
7	80214	35·809	197023	87·952	·156	
8	88134	39·345	216465	96·636	·205	
9	91840	41·000	225568	100·700	·233	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·233. By formula (13).—The work (u) expended in producing rupture =26217.

Exp. XLI.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Mark on bar, "F."

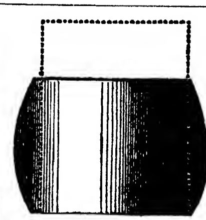
	Before experiment.		After experiment.
Height of specimen..........	1·0 inch.	....	·748 inch.
Diameter of specimen........	·72 inch.	....	·785 inch.
Area of specimen	·40715 sq. in.	....	·48398 sq. in.

No. of Expt.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·020	
2	44966	20·074	110440	49·303	·025	
3	52166	23·288	128124	57·198	·033	
4	58950	26·316	144786	64·637	·049	
5	66022	29·474	162156	72·391	·078	
6	73134	32·649	179722	80·233	·127	
7	80214	35·809	197023	87·952	·176	
8	88134	39·345	216465	96·636	·225	
9	91840	41·000	225568	100·700	·253	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·253. By formula (13).—The work (u) expended in producing rupture =28467.

Exp. XLII.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Mark on bar, "G."

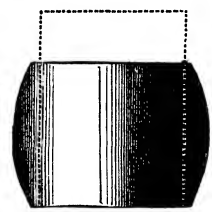
	Before experiment.		After experiment.
Height of specimen..........	·998 inch.	....	·71 inch.
Diameter of specimen........	·72 inch.	....	·79 inch.
Area of specimen	·40715 sq. in.	....	·49016 sq. in.

1	37438	16·713	91951	41·049	·030	
2	44966	20·074	110440	49·303	·035	
3	52166	23·288	128124	57·198	·053	
4	58950	26·316	144786	64·637	·079	
5	66022	29·474	162156	72·391	·118	
6	73134	32·649	179722	80·233	·167	
7	80214	35·809	197023	87·952	·216	
8	88134	39·345	216465	96·636	·265	
9	91840	41·000	225568	100·700	·293	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·293. By formula (13).—The work (u) expended in producing rupture =32968.

Exp. XLIII.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Mark on bar, "H."

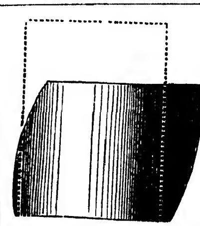
	Before experiment.		After experiment.
Height of specimen	·993 inch.	....	·731 inch.
Diameter of specimen	·72 inch.	....	·776 inch.
Area of specimen	·40715 sq. in.	....	·47294 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·020	
2	44966	20·074	110440	49·303	·025	
3	52166	23·288	128124	57·198	·043	
4	58950	26·316	144786	64·637	·059	
5	66022	29·474	162156	72·391	·088	
6	73134	32·649	179722	80·233	·137	
7	80214	35·809	197023	87·952	·196	
8	88134	39·345	216465	96·636	·245	
9	91840	41·000	225568	100·700	·273	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·273. By formula (13).—The work (u) expended in producing rupture =30718.

Exp. XLIV.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Mark on bar, "1."

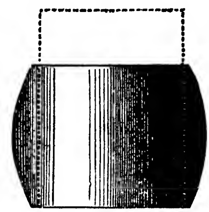
	Before experiment.		After experiment.
Height of specimen	·988 inch.	....	·722 inch.
Diameter of specimen	·72 inch.	....	·781 inch.
Area of specimen	·40715 sq. in.	....	·47783 sq. in.

1	37438	16·713	91951	41·049	·020	
2	44966	20·074	110440	49·303	·025	
3	52166	23·288	128124	57·198	·043	
4	58950	26·316	144786	64·637	·059	
5	66022	29·474	162156	72·391	·108	
6	73134	32·649	179722	80·233	·157	
7	80214	35·809	197023	87·952	·206	
8	88134	39·345	216465	96·636	·255	
9	91840	41·000	225568	100·700	·273	Very slightly cracked.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·273. By formula (13).—The work (u) expended in producing rupture =30718.

EXP. XLV.—Bar of Steel from Messrs. Turton & Sons, Sheffield. Mark on bar, "U."

	Before experiment.		After experiment.
Height of specimen..........	·984 inch.	....	·701 inch.
Diameter of specimen........	·72 inch.	....	·785 inch.
Area of specimen............	·40715 sq. in.	....	·48398 sq. in.

No. of Exp.	Weight laid on specimen.		Weight laid on per square inch of section.		Compression, in inches.	Remarks.
	lbs.	tons.	lbs.	tons.		
1	37438	16·713	91951	41·049	·030	
2	44966	20·074	110440	49·303	·035	
3	52166	23·288	128124	57·198	·053	
4	58950	26·316	144786	64·637	·069	
5	66022	29·474	162156	72·391	·118	
6	73134	32·649	179722	80·233	·167	
7	80214	35·809	197023	87·952	·226	
8	88134	39·345	216465	96·636	·275	
9	91840	41·000	225568	100·700	·293	No cracks.

Results.—Here the strain per square inch (P_1) causing rupture is 225,568 lbs., or 100·7 tons; and the corresponding compression (l_1) per unit of length is ·293. By formula (13).—The work (u) expended in producing rupture =32968.

Summary of Results of the Experiments on Compression.

No. of Exp.	Manufacturers.	Mark on bar.	Greatest weight laid on per square inch.		Corresponding compression per unit of length.	Value of u, or work expended in crushing the bar. By eq. (13).	Remarks.
			lbs.	tons.			
	Messrs. Brown and Co.						
1	Best cast steel from Russian and Swedish iron, for turning-tools	B 1	225568	100·700	·253	28533	One very slight crack appeared.
2	Ditto, milder	B 2	225568	100·700	·263	29592	No cracks.
3	Cast steel from Swedish iron, for tools	B 3	225568	100·700	·183	20591	One very slight crack of outside skin.
4	Ditto, milder, for chisels	B 4	225568	100·700	·293	32968	No cracks.
5	Ditto, mild, for welding	B 5	225568	100·700	·243	27342	"
6	Bessemer steel	B 6	225568	100·700	·403	45345	"
7	Specimen of double shear steel from Swedish iron	B 7	225568	100·700	·443	49846	Three large cracks, with several smaller ones.
8	Do. do. foreign bar, tilted	B 8	225568	100·700	·493	55472	Much cracked.
9	English tilted steel made from English and foreign pigs	B 9	225568	100·700	·553	62223	"
	Messrs. Cammell and Co.						
10	Specimen of cast steel, termed "Diamond Steel"	1	225568	100·700	·233	26217	No cracks.
11	Do. cast steel, termed "Tool Steel"	2	225568	100 700	·263	29592	"
12	Do. cast steel, termed "Chisel Steel"	3	225568	100·700	·313	35218	"
13	Do. cast steel, termed "Double Shear Steel"	4	225568	100·700	·303	34171	Very slight cracks.
14	Bar of hard Bessemer steel	5	225568	100·700	·433	48721	No cracks.
15	Bar of soft Bessemer steel	6	225568	100·700	·493	55472	"
	Messrs. Naylor, Vickers and Co.						
16	Cast steel called "Axle Steel"	A	225568	100·700	·423	47596	No cracks.
17	Do. do. "Tyre Steel"	T	225568	100·700	·388	43758	"
18	Do. do. "Vickers's Cast Steel, Special"	S	225568	100·700	·153	17255	"
19	Do. do. "Naylor and Vickers's Cast Steel"	S 26	225568	100·700	·183	20591	"

	Samuel Osborn, Esq.						
20	Specimen of best tool, cast steel	O 1	225568	100·700	·203	22841	No cracks.
21	Do. best chisel	O 2	225568	100·700	·243	27342	"
22	Specimen of best cast steel for hot and cold sates-cups, shear-blades, and boiler-maker's steel	O 3	225568	100·700	·253	28467	"
23	Best cast steel for taps and dies	O 4	225568	100·700	·263	29592	"
24	Toughened cast steel for shafts &c.	O 5	225568	100·700	·323	36344	"
25	Specimen of best double shear steel	O 6	225568	100·700	·323	36344	"
26	Extra best tool, cast steel	O 7	225568	100·700	·193	21716	"
27	Cast steel for boiler-plates	O 8	225568	100·700	·333	37469	"
	Messrs. Bessemer and Co.						
28	Specimen of hard Bessemer steel	B S 1	225568	100·700	·223	25092	No cracks.
29	Do. of milder quality	B S 2	225568	100·700	·443	49846	"
30	Do. of soft	B S 3	225568	100·700	·473	53222	"
	Messrs. Sanderson and Co.						
31	Bar of cast steel from Russian iron suitable for welding	S 1	225568	100·700	·398	44783	Two large cracks.
32	Specimen of double shear steel	S 2	225568	100·700	·303	34093	Very slight crack.
33	Do. single do.	S 3	225568	100 700	·283	31843	No cracks.
34	Bar of faggot steel	S 4	225568	100·700	·323	36344	Several slight cracks.
35	Specimen of drawn bar	S 5	225568	100·700	·333	37469	Much cracked.
	Messrs. Turton and Sons.						
36	Steel used in the manufacture of cups	A	225568	100·700	·283	31843	No cracks.
37	Do. do. do. drills	B	225568	100·700	·193	21716	"
38	Do. do. do. cutters	C	225568	100·700	·243	27342	"
39	Do. do. do. turning-tools	D	225568	100·700	·263	29592	"
40	Do. do. do. machinery	E	225568	100·700	·233	26217	"
41	Do. do. do. punches	F	225568	100·700	·253	28467	"
42	Do. do. do. mint dies	G	225568	100·700	·293	32968	"
43	Do. do. do. dies	H	225568	100·700	·273	30718	"
44	Do. do. do. taps	I	225568	100·700	·273	30718	Very slightly cracked.
45	Specimen of double shear steel	U	225568	100·700	·293	32968	No cracks.

Abstract of the Results of Tables I., II., and III.

Transverse Strain.—Table I.

The results of these experiments show that, *within the elastic limits*, the deflections are in proportion to the pressures; for example, in Experiment 1, the deflections are almost exactly expressed by the formula $\delta = \cdot 001361\ w$, where the constant ·001361 is the mean, D_1, of all the deflections for a unity of weight derived from formula (3). By aid of this principle the value of the weight, w, with its equivalent deflection, corresponding to the elastic limit, was determined.

The mean value of D_1, given in col. 4, the deflection corresponding to unity of pressure and section, may be taken as the *measure of the flexibility* of the different bars. In general, the least flexible bars give the highest values of E and C, and, other things being the same, or nearly the same, the most flexible bars give the highest values of u, the work of deflection corresponding to unity of section.

The bars of some of the experiments, 10, 18, 28, &c., with more than an average flexibility, gave very high values for C, the working unit of resistance to transverse strain, showing their great value when applied to the springs of carriages and other constructions, where flexibility and strength should be combined. Such bars as those of experiments 1, 12, 21, &c., with less than an average flexibility, gave at least an average value for C, showing their applicability to all constructions where rigidity and strength are required; and so on to other cases.

The mean value of E, the modulus of elasticity, given in col. 5, taken for thirty of the best specimens, is 31,000,000 nearly, whilst the mean taken for a like number, in col. 4, is about 32,000,000. This modulus exceeds that of wrought iron by more than the 30th part. Steel having a much greater flexibility than wrought iron, accounts for the approximation of their values for the modulus of elasticity. The bars that have the greatest flexibility, or the great value of D_1, other things being the same, have the least value for the modulus of elasticity.

The values of u, or the work of deflection for the unity of section up to the elastic limit, may be taken as measures of the qualities of bars where flexibility and strength are required.

The bars generally exhibit very high powers of resistance to transverse strain. The mean value of the unit of working strength, C, given in col. 9, taken for one-half the number of experiments, is 6·83 tons, and for the remaining half (omitting the last two experiments) this constant is 5·23 tons, giving a general mean of 6 tons. In the model tube of the Britannia and Conway bridges, the value of the constant for *breaking* weight is 6·7 tons.

Taking 11 tons per square inch as the mean value of the compressive and tensile resistances of wrought iron at the elastic limit, the value of C in this case will be less than 2 tons; hence it follows that the transverse strength of these steel bars will be about $3\frac{1}{2}$ times the strength of wrought-iron bars of the same dimensions.

In order to determine the relative value of the two kinds of material undergoing transverse strain, let us suppose two bars of the same length, one steel and the other iron, having the same strength, to be similar in their transverse sections; then, as the strength of bars of similar section are as the cubes of their depths,

$$d_1=\sqrt[3]{\frac{C}{C_1}}\times d=3{\cdot}5^{\frac{1}{3}}\times d,$$

where d is the depth of the steel bar, d_1 that of the iron bar, and $\frac{C}{C_1}=3{\cdot}5$, the ratio of their units of working strength.

But as the areas of similar section are as the squares of their like dimensions,

$$\frac{\text{Section iron bar}}{\text{Section steel bar}}=\frac{3{\cdot}5^{\frac{2}{3}}\,d^2}{d^2}=3{\cdot}5^{\frac{2}{3}}=2{\cdot}3052.$$

Now taking the cost of iron at £7 per ton, and that of steel at £12, we have for the relative cost of the two materials of the same strength,

$$\frac{\text{Iron}}{\text{Steel}}=\frac{7\times 2{\cdot}3052}{12}=\frac{16{\cdot}1364}{12}=1{\cdot}3447,$$

that is, the cost of the iron would be about $1\frac{1}{3}$ times that of the steel.

In the case of railway bars and such constructions, besides this saving in the cost of material, it must be borne in mind that the steel rail would last four times as long as the iron rail.

Tensile Strain.—Table II.

Taking the mean of the results of the experiments on thirty of the best specimens, we find the mean tenacity per square inch $=47{\cdot}7$ tons.

Now if we take 25 tons per square inch as the tenacity of the best English hammered iron in bars, it follows that the tenacity of these steel bars will be about twice (1·91 time) that of the iron bars.

Economic use of the Material.

For bars of equal strength, undergoing tensile strain, the iron bar should be about twice the section of the steel bar; now if the cost of steel be £12 per ton, and that of iron £7, then, for a ton of metal in each case, the comparative cost of bars of equal strength will be

$$\frac{\text{Iron bars}}{\text{Steel bars}}=\frac{7\times 1{\cdot}91}{12}=\frac{13{\cdot}37}{12}=1{\cdot}114;$$

that is, the cost of the iron would be more than once and one-tenth that of the steel; in this case, therefore, the steel would be the more economical metal. The saving per ton of material would be £1·37, or £1 7*s*. $4\frac{3}{4}$*d*.

The work producing rupture in the different specimens is very variable, owing probably, to some extent, to the errors arising from the determination of such exceedingly small elongations. This irregularity would have been avoided if the specimens had been of greater length, so that the elongations might have been ascertained with greater accuracy.

The greatest value (6403) of this work of elongation is given in expt. 14, where the breaking strain of the specimen is below the average, being only about 40 tons per square inch.

The specimen (see expt. 18) which had the greatest tenacity, viz. about 60 tons per square inch, required only 670 units of work to produce rupture; this arises from the very small elongation, viz. ·01, which the bar sustained at the point of rupture.

The ultimate elongations are unaccountably variable, and seem much below what might have been expected; even the greatest elongation, ·1437, given in the Table, is below the average for iron bars, whilst the least elongation, ·0037, produced by a strain of $38\frac{1}{4}$ tons per square inch, is only about the 50th part of this average.

Compression.—Table III.

Thirty-two of the bars supported each a pressure of 100·7 tons per square inch of section without undergoing any sensible fracture, whilst twenty-three bars were more or less fractured with this pressure.

The mean value of the compression per unit of length, given in col. 6 of the Table, taken for 24 of the best specimens, is ·372; whilst the mean taken for the remaining specimens is ·232, giving a general mean deflection of ·302.

The work, u, expended in crushing the material in short columns is remarkably large. The mean value of u, given in col. 7, taken for 26 of the best specimens, is 41300; whilst the mean taken for the remaining specimens is 25400, giving a general mean value of 33400.

If 6000 be taken as the value of u, in the case of tensile strain, then the work expended in rupturing the material by compression will be $5\frac{1}{2}$ times the work expended in rupturing the material by extension.

Tensile and compressive Resistances compared.

Taking the mean tensile resistance to rupture at 47·7 tons per square inch, it follows that their resistance to compression is more than double ($2\cdot\dot{1}$ times) their resistance to extension: thus $\frac{100\cdot7}{47\cdot7}=2\cdot\dot{1}$. Hence it follows that the most economic form of a steel bar undergoing transverse strain would be a bar with double flanches, having the area of the bottom flanch about double that of the top flanch.

This conclusion is borne out by the results of experiments on transverse strain, where S_1, the strain per square inch of the material at the elastic limit, $=6C=6\times6\cdot83$ tons $=40\cdot98$, or 41 tons nearly; but the mean breaking strain per square inch by extension $=47\cdot7$ tons, clearly indicating that the compressive resistance in the former case was considerably in excess of the tensile resistance.

It is important in every experiment on the strength of materials, which enters so largely into constructive art, that we should be thoroughly acquainted with the properties of the material of which the structure is composed, and that its resistance in all the different forms of strain should be clearly and distinctly ascertained. In the foregoing experiments we have determined the resisting powers of the different specimens to bending, tension, and compression; but we have omitted that of torsion, or twisting, until we have an opportunity of doing so upon the same identical bars. These I hope to accomplish in a separate communication, and also to give some further results on an enlarged scale, calculated to confirm what has already been done, and to ascertain some additional facts in regard to the changes now in progress in the manufacture of Bessemer steel.

Report of the Committee appointed to explore the Marine Fauna and Flora of the South Coast of Devon and Cornwall.—No. 2. *Consisting of* J. Gwyn Jeffreys, *F.R.S.*, Rev. Thomas Hincks, Jonathan Couch, *F.L.S.*, Charles Stewart, *F.L.S.*, J. Brooking Rowe, *F.L.S.*, *and* J. Ralfs, *F.L.S.* *Reporter*, C. Spence Bate, *F.R.S.* *&c.*

In presenting their Second Report, the Committee beg to state that their endeavour has been, as much as possible, to direct their researches towards the discovery of rare or new species,—to retake, upon the ground on which they were originally found, specimens similar to those that have been described by Leach and Montagu, some of whose typical specimens have been lost, misplaced, or destroyed. This is more true in regard to the Crustacea than perhaps of any other class of animals—a circumstance, when taken in connexion with the curt descriptions of the animals given by the authors, that materially interferes with the power of zoologists to pronounce with confidence upon the relation that any fresh specimens may bear to those types.

To carry out this plan as much as possible, we have directed our investigations hitherto mostly between Bigbury Bay toward the east, and the Dodman toward the west. Within these limits our dredging and trawling has been mostly carried on within a distance of about twenty miles of the shore, and in water that has not exceeded fifty fathoms in depth.

Fish.—As regards the obtaining of fish, the sweep of a dredge, Mr. Couch says, is too limited to afford a prospect of much success; and our notes about them can be but few. In shallow depths the Megrim or Scaldfish (*Rhombus arnoglossus*) was obtained in abundance; but none were found at between forty and fifty fathoms. At the latter depth the Launcelet and larger Launce had lain buried in the sand; as regards the latter, it seems worthy of notice that at this season the large abundance of its species have changed their quarters so as to approach the shore, while at least in this one instance an example has remained buried in its winter haunt. An observation made by an intelligent fisherman may also be deserving of notice. It refers to the habit of some small individuals of several kinds of fish seeking shelter within the cavity of some of the larger species of medusæ. Very small Scads, Bibs, and Whiting Pollacks are often found thus attending on these medusæ, so as to accompany them wherever they float; and on the least alarm they have recourse to the shelter thus offered to them; so that on lifting one of these creatures into the boat there were found concealed within the cavities no less than *sixty-two* young Scads—from which the question arises, As these medusæ are generally believed to come to us from a warmer region, may they not be the means of conveying to us young fishes of rarer sorts, which otherwise might not have visited us?

Among the rarer fishes which have come to our knowledge since our last Report to the Meeting of the British Association, I may be permitted to mention *Ausonia cuvieri*, of which an account is given in the Journal of the Zoological Society,—and also what there is some reason to judge a distinct species, to which the name has been assigned of *A. cocksii*. We have had also the Scabbard fish (*Lepidopus argyreus*), which was found floating on the surface near Falmouth, and also the Silvery hairtail (*Trichiurus lepturus*) taken in a drift-net near Penzance.

Mollusca.—*Rostellaria pes-pelecani*, in all stages of growth; *Psammobia vespertina*, *Crassina danmonii*, *Cardium espinatum*, *C. levigatum*, *Cerithium lima*, *Acmæa virginea*, from a trawl (but this example differs from the figure

given by Forbes, as if from greater age), *Chione islandica*, *Venus sarniensis*, *V. fasciata*, *Solen pellucidus*, *Saxicava arctica*, *Lima hians*, or *L. losiconii* (a single valve from thirty-five fathoms); *Pectens*, numerous, among them *P. tigrinus*, but all empty shells; *Dentalium entalis*; *D. tarentinum* (?), *Pilidium fulvum*, on the dead shell of *Pinna nigra*; *Fusus propinquus*; *F. longirostris*, from forty fathoms; *Bulla lignaria*; *Turritella terebra*; *Trochus papillosus*; *Scalaria clathratulus*; *Natica alderi*; *N. nitida*, from the stomach of *Asterias aurantiaca*; *Pandora inæquivalvis*; two or three examples of a genus which Forbes terms *Trophon*, but of which he has not given figures; *Emarginula rosea*; *Marginella rosea*.

CRUSTACEA.—The Reporter states that the number of Crustacea that have been taken off this south-western coast of England has been very large, being, with few arctic exceptions, the whole that have hitherto been known to the British seas, to which we have the pleasure of adding several interesting and important species.

The entrance to the English channel appears in its position to be the boundary or extreme limits of two several faunas. We find species that are decidedly arctic in their character represented by specimens that have a generally depauperized appearance, both as to size and typical expression, while Mediterranean species are represented without any large amount of variation in form or dimensions of specimens. But our observations induce us to believe that the southern forms, when taken on our shores, are generally dredged from water of considerable depth, whereas those of the arctic types are as invariably taken in shallow water.

The variation of depths and local habitats appear to us to depend more upon the condition of food and its general supply than from other causes; we therefore think that the geographical distribution of animals in limited regions can only be worked out by a previous knowledge of the history of the animals, particularly in relation to their food—and even then cannot be very reliable.

The annexed list of Crustacea exhibits the various species that have been recently taken by members of this Committee.

BRACHYURA.

	Range	Ground.	Frequency.
Stenorhynchus, *Lamarck.*	Fath.		
phalangium, *Penn.*	3–45	Zoophytic.	Common.
tenuirostris, *Leach* ...	6–30	Zoophytic.	Frequent.
Achæus, *Leach.*			
cranchii, *Leach*	6–20	Zoophytic.	Occasionally.
Inachus, *Fabr.*			
dorsettensis, *Penn.*	5–30	Rocky.	Occasionally.
Pisa, *Leach.*			
tetraodon, *Leach*	10–20	Weedy.	Not common.
Hyas, *Leach.*			
aranea *Fabr*...............	6–40	Weedy.	Frequent.
Maia, *Lam.*			
squinado, *Herbst*	3– 8	Weedy.	Frequent.
Eurynome, *Leach.*			
aspera, *Leach*	4–40	Weedy.	Frequent.
Xantho, *Leach.*			
florida, *Leach*..............	6–20	Rocky.	Occasionally.
rivulosa, *Ed.*	6–20	Rocky.	Occasionally.
tuberculata, *Couch*........	4–45	Stony.	Frequent.

BRACHYURA—*continued.*

	Range.	Ground.	Frequency.
Primula, *Leach.*			
denticulata, *Mont.*	4 3	Zoophytic.	Frequent.
Carcinus mænas, *Linn.*	0– ½	Rocky.	Common.
Portunus, *Leach.*			
puber, *Linn.*	0– 1	Rocky.	Frequent.
depurator, *Leach*	4–45	Zoophytic.	Occasionally.
marmoreus, *Leach.*	3–45	Zoophytic.	Occasionally.
pusillus, *Leach*	5	Rocky.	Occasionally.
Polybius, *Leach.*			
henslowii, *Leach*	....	Trawled.	Occasionally.
Pinnotheres, *Latr.*			
pisum, *Penn.*	0	Oyster-bed.	1 in mussel, Saltash.
veterum, *Bosc* .	30	Stony.	1 in *Pinna.*
Gonophax, *Leach.*			
angulata, *Leach.*. ..	12	Zoophytic.	Occasionally.
Planes, *Leach.*			
linnæana, *Leach*	.. ..	On living turtle.	2 near French coast.
Ebalia, *Leach.*			
pennantii, *Leach*	40	.. ...	Frequent.
bryerii, *Leach*	4–45	Shelly.	Frequent.
cranchii, *Leach*	40–45	Shelly.	Frequent.
Atelecyclus, *Leach.*			
heterodon, *Leach*	30–45	Stony.	Occasionally.
Corystes, *Leach.*			
cassivelaunus, *Leach*......	12	Zoophytic.	Common.

ANOMURA.

	Range.	Ground.	Frequency.
Pagurus, *Fabr.*	Fath.		
bernhardus, *Linn.*.. ..	0–30	Stony.	Common.
prideauxii, *Leach*	6–45	Zoophytic.	Occasionally.
cuanensis, *Thom.*	3–10	Rocky.	Not common.
hyndmanni, *Thom.* .. .	6	Mud and stone.	Occasionally.
lævis, *Thom.*	4–10	Rocky.	Occasionally.
dillwynii, *Sp. B.*	0– 6	Sand, rocky.	Common at Exmouth, occasionally at the mouth of the Yealm.
Porcellana, *Lam.*			
platycheles, *Penn.*..	0– 3	Rocky.	Common.
longicornis, *Penn.*..... ..	4–40	Zoophytic, rocky.	Common.
Galathea, *Fabr.*			
squamifera, *Leach*	12	Zoophytic.	Occasionally.
dispersa, *Sp. B.*..........	4–40	Zoophytic.	Common.
strigosa, *Fabr.*	0–10	Stony.	Common.
nexa, *Emb.*	40	Shelly.	Occasionally.
andrewsii, *Kin.*	10–45	Zoophytic.	Frequent.
bamffica, *Penn.* (Munida rondeletii, *Bell*)	20–30	Stony.	Occasionally. Mr. Couch says, common in stomach of codfish.
digitidistans, *Sp. B.*	30	Stony.	2 specimens.

MACRURA.

	Range.	Ground.	Frequency.
Scyllarus, *Fabr.*	Fath.		
arctus, *Linn.*	6	Rocky.	5 specimens: 1 Plymouth, 1 Polperro, and 3 Penzance.
Palinurus, *Fabr.*			
vulgaris, *Latr.*	3–10	Rocky.	Common.
Callianassa, *Leach.*			
subterranea, *Leach*	4	Mud.	1 specimen.
Homarus, *M.-Ed.*			
marinus, *Fabr.*	1– 6	Rocky.	Common.
Crangon, *Fabr.*			
vulgaris, *Fabr.*	0–40	Sand.	Common.
boreas, *Phipps* (fasciatus, *Risso*, sculptus, *Bell*)	20	Stony.	Occasionally.
spinosus, *Leach*	6–15	Zoophytic.	Frequent.
trispinosus, *Hailstr.*	6	Rocky.	4 specimens, Bigsby Bay.
Alpheus, *Fabr.*			
ruber, *Edw.*	30	Stony.	Several specimens.
edwardsii	30	Stony.	Several specimens.
Typton, *Costa.*			
spongiosum, *Sp. B.*	4	Stony.	4 specimens in a sponge.
Nika, *Risso.*			
edulis (*Risso*), couchii, (*Bell*)	30	Stony.	Occasionally.
Athanas, *Leach.*			
nitescens, *Mont.*	...	....	Off Polperro.
Hippolyte, *Leach.*			
cranchii, *Leach*	6–10	Stony.	Common.
Caradina, *Edw.*			
varians, *Leach*	6–10	Stony.	Common.
tenuirostris, *Sp. B.*	4– 6	Stony.	Several.
Pandalus Jeffreysii (*Sp. B.*), (Thompsoni?, *Bell*)	6	Rocky.	
Palæmon, *Fabr.*			
serratus, *Penn.*	1–40	Rocky.	Common.

Among the Brachyura we know not of any that call for especial remark, except *Planes linnæana*, of which Mr. Couch says, "In the spring of the present year (1867) an example of the Hawk's-bill Turtle was taken in the Channel, at not a great distance from the French coast, and therefore not to be classed as British; but when brought alive and active to Polperro, there were found, adhering closely under the shelter of its tail, two full-grown examples of the Crab *Planes linnæana*,—the situation evidently chosen for support and shelter; for, from the structure of their hind legs, it does not appear probable that they can maintain themselves at the surface without the aid of some extraneous support."

These would not have been recorded here if the species had not previously been taken on our coast; for there can be little doubt that they are mere strangers; and the specimens having been taken attached to a living turtle corroborates the fact, while it also shows that the exotic reptile must have gathered them as it travelled by the Sargossa weed.

Amongst the anomurous Crustacea we would wish to notice the genus that Leach has named *Munida* in order to distinguish it from that of *Galathea*; but the points of distinction are not sufficient to warrant so great a separation, and naturally they appear to us to be but species of one genus.

We have recently taken three fine specimens on the shelly ground off the Dodman in about thirty fathoms of water. The first specimen that we obtained differed from those previously known and described by having, instead of a long central rostriform spine flanked by two shorter ones of analogous construction, three equally important anteriorly porrected spines—this in consequence of the two lateral spines being developed to a length corresponding with that of the central in normal specimens; whilst in another specimen the central spine appears to be rather longer in proportion to the lateral ones than that figured by either Leach or Prof. Bell, and the specimen bears a very close relationship to *Galathea monodon* of Milne-Edwards from Brazil—a circumstance that supports an opinion that we have elsewhere expressed, that there is a very considerable resemblance between the crustacea of the South-American coast and that of the British seas.

This species, *Galathea bamffica* (*Munida rondeletii*, Bell), is stated to be one of the rarest of our crustacea, and is seldom to be met with in our museums. Its habitat is most probably the temperate latitudes in tolerably deep water on the western shores of Europe; for although extending as far as the Shetlands, yet the specimens that have been dredged in the colder regions are, we believe, invariably very small and the inhabitants of very deep water.

Among the *Galatheæ* that we have taken on our coast, and which embrace all that have been previously known as British, is one that we think must be accepted as not having been previously described.

The largest specimen, measuring from the extremity of the tail to that of the extended hands, is little more than two inches, of which the animal itself, measuring from the extremity of the rostrum to that of the tail, is little more than one inch. This species differs from either of the others in having the large pair of chelate pereiopoda flat and broad, the fingers much curved, very distant, and meeting only at their apex when closed, furnished on the inside with a considerable brush of hairs, and armed near the base of the moveable finger with a prominent tubercle or tooth, but which appears to be of little importance, since it is not able to impinge against the opposite finger. We have sometimes thought that this specimen may only be an extreme form of the male of *Galathea squamifera*; but the armature of the surface of the hands, which is generally a safe guide in specific character, has a distinct variation. In *G. squamifera* the arms are covered generally with a series of curved scale-like tuberculations, the anterior margin of which is divided into a series of bead-like elevations, while in the most typical parts, such as on the surface of the meros and carpus, the central prominence is elevated to a point, and the whole of the tubercular ridge is crowned by a row of short hairs so minute that they are not perceptible except by the assistance of a lens. These tuberculations are closely packed and regular.

In the supposed new species the tuberculations are less prominent and defined, the margins of which can only be perceived to be at all baccated by careful arrangement of the light, while the cilia, being far less numerous, are yet more conspicuous under the lens. If it be only a variation of *G. squamifera*, as we are much inclined still to consider it, it is too important a variation to be passed over without notice, and the Reporter has named it provisionally *Galathea digitidistans*, until the observation of a larger series of specimens than we have as yet seen may enable us to arrive at a correct conclusion.

The zoë of the genus *Porcellana* has, we believe, been figured from exotic species by Dana; and having the opportunity of observing that of *P. platy-*

cheles, we have taken advantage of the circumstance (Pl. I. fig. 4). It differs from the recognized typical zoë of the common shore-crab (*Carcinus mænas*) in the monstrous development of an anterior and two posterior cornuous processes to the carapace, and in the formation of the telson; but in its complete character it offers an intermediate condition between the larvæ of the brachyurous and macrurous crustacea. It has the appendages of the cephalon and pereion developed to a similar extent with those of the Brachyura, whereas the telson and carapace bear a nearer resemblance to the same parts in the Macrura, from which they differ in degree only. In the carapace, instead of the rostrum and the posterior angles of the carapace being only just pronounced, as in the macrurous zoe, they are developed to a larger extent in the anomurous larvæ, and in the young of the *Porcellanæ* to nearly twice or three times the length of the animal; while the telson, instead of being shaped like the caudal fin of a fish, has in the Anomura the central portion sometimes produced to an angle posteriorly.

Beyond this stage of the development of this species, or, we believe, any species of the Anomura, we have no sure knowledge, except that which we stated in the last Report relative to the genus *Glaucothoë* being a stage in the development of the genus *Pagurus*.

The zoë of *Pagurus* (Pl. I. fig. 1) is probably tolerably well known to carcinologists, but we are not aware of its having been figured or described. It has the anomurous character of having a pointed rostrum and a projecting point at each of the posterior angles of the carapace, and the telson terminating in a gradually widening fishtail-like appendage, fringed with a few terminal spines—the appendages being developed rather on the type of those of the Brachyura than of the Macrura. During our expeditions we have taken specimens that we believe to be the zoe of the same genus still further developed; we say believe to be, because it is only from analysis that we have come to this conclusion, and we have not the testimony of direct observation that the one is the older stage of the other.

That which we take to be the second stage of the genus *Pagurus* (Pl. I. fig. 2) we took, in the latter end of May, in a towing-net, in Plymouth Sound. From its general appearance our first impression was that it was the young of a *Palæmon*; but closer observation and a careful dissection of its parts induce us strongly to believe that it is the young of one of the anomurous group of Crustacea,—in the first place the form of the carapace, in the next the general divergence from and the resemblance to the appendages of the zoë of a macrurous decapod. The superior antenna is developed upon the brachyurous type, but the inferior has the squamiform appendage of the macrurous crustacea. All the other appendages that pertain to the cephalon and pereion, except the last pair of pereiopoda (and these are not developed, at least they were not perceptible to our examination), have the macrurous type—a circumstance that would accord with the animal being that of an undeveloped anomurous crustacean. The pleon and its appendages bear a very close resemblance to those of the larva of a prawn, since it is equilaterally developed and furnished with a pair of appendages, posteriorly and ventrally, attached to each somite, the last of which is much larger than the others, and is evidently a progressive stage in the development of the great caudal plates of the macrurous crustacea.

We attribute it to the genus *Pagurus* rather than to any of our other anomurous crustacea, because it differs from the known zoe of *Porcellana*, and of that of *Galathea* we have no knowledge; but from the nearer approach of these last genera to each other in their adult stage than to

Pagurus, we are inclined to believe in a near resemblance of their larvæ. Hence our assumption that this present immature species is a young *Pagurus.*

The next stage (Pl. I. fig. 3) to which we allude is one that we noticed in our preliminary Report to this Association.

The animal is a small creature that we took floating near the surface of the sea in a warm day in June. Its general appearance is that of a young macrurous crustacean; and as such has been classified near to *Callianassa* and *Calliadina*. It is symmetrical, except in the larger development of the great chela of the right side. The two succeeding pereiopoda are very long, but simple, in their formation. The last two are considerably reduced in size; and the anterior terminates in a small imperfectly didactyle forceps; and the posterior has a copious brush, consisting of cilia and short and broad spines, amongst which the short obtuse and spinous dactylos is discernible. The pleon is well developed, having each somite clearly defined, and all, except the first, carrying an equally developed pair of appendages, each of which consists of a peduncle and two unequal rami. The posterior pair, or uropoda, differ from the others in having the peduncle shorter, and the outer ramus longer and more robust; it is likewise, in the older specimens, curved slightly more on the left side than on the right.

In this condition they probably continue until they find a suitable molluscous shell in which to reside. We imagine that they may continue to cast their exuvia and grow according to the length of time that they are deficient of such shell, because we have taken specimens occupants of shells that are still smaller than the one described, and yet further advanced to maturity. It would be curious to see if, when deprived entirely of the use of a shell for a habitat, they should continue to grow and retain the normal form of the pleon generally—a feature that characterizes some of the exotic closely allied genera.

Thus a careful examination of numerous specimens has enabled us to demonstrate the progressive development of the genus *Pagurus*, and to affirm with much confidence, judging by the descriptions and figure of the authors, that the genera *Glaucothoe* of M.-Edwards, and *Prophylax* of Latreille, are none other than an immature stage of the genus *Pagurus*; but since their specimens were exotic, they were probably the young of some foreign species.

Amongst the macrurous crustacea, we have had the opportunity of examining and figuring the larva of *Palinurus* (Pl. II. fig. 2). The young of this genus was first made known to this Association by the late Mr. R. Q. Couch of Penzance, at the Meeting at Dublin in 1857, when he drew attention to the near resemblance existing between it and the genus *Phyllosoma*. In 1864–65 M. Gerbe (see the 'Comptes Rendus') repeated the discovery of Mr. Couch, and asserts that the larva of *Palinurus* is identical with the genus *Phyllosoma.*

The larva of most of the decapod crustacea has the largest amount of development, commencing with the cephalon and the pleon; whilst in the larva of the *Palinurus* the greatest advancement exists in the anterior part of the cephalon and in the pereion, whereas the pleon is almost rudimentary.

On comparing it with the genus *Phyllosoma* (Pl. II. fig. 1), as M. Gerbe has done, there is little in the general structure of the animals that can warrant a separation of the two, or that might not be accounted for by an increasing development of the younger specimens. Yet there are certain points that weigh heavily in the balance of evidence against the larva of *Palinurus* and *Phyllosoma* being but different stages of the same animal:—

(1) It is contrary to our experience that so small an amount of progressive development shall have taken place in an animal that has increased in growth to about thirty times its size. We generally perceive in the development of crustacea that the most important changes are those that imme-

diately succeed the birth of the larva. (2) The most certain mark by which a young animal may be known is the immature condition of the antennæ, more especially the flagella; now, whilst in the larva of the *Palinurus* they are very rudimentary, in *Phyllosoma* they assume an adult character, and, in the second pair, one that is of a peculiar feature, at least in the species to which we refer. (3) The oral appendages appear to be present, though only as the germs of the future parts, whilst in *Phyllosoma* they appear to exist in a rudimentary condition that assimilates little to a progressive stage. (4) Double branchial vesicles are attached to the coxæ of each pair of pereiopoda, whilst none exist in the larva of *Palinurus*. We must admit, however, that this argument is not very strong, seeing that in the adult *Palinurus* branchial organs are present, and that there must be a period when they first appear; and it is most probable that their earliest stage is of the most simple character. And perhaps we should not have thought it sufficiently important to have remarked upon, had not M. Gerbe stated that *Phyllosoma*, like the larva of *Palinurus*, was without branchial appendages; and M. M.-Edwards remarked that these vesicular appendages are vestiges of the external branch of the limbs. (5) *Phyllosoma* is a tropical genus, and with such we can only compare the larva of *Palinurus*; two specimens only of the former have been obtained in the British seas, whereas *Palinurus* is very common on our coasts—an argument that might be very forcible were we not cognizant of the fact that we are quite as much, if not more, in the dark in relation to the development of the common lobster.

Our ignorance upon these interesting and important points in the history of the crustacea, together with the discovery of Fritz Muller, that the larva of *Peneus*, and probably that of some other prawns, very closely resembles that of the cirripedes and other entomostracous larvæ, shows that there is much yet to be done of far more interest to zoological science than the mere discovery of new species to be added to our fauna. The great diversity of structure and the wonderful variation in the development of animals that possess a great similarity in their adult condition indicate that careful study of these animals will probably assist in throwing considerable light on some of the more profound problems of biological knowledge.

Several specimens of *Scyllarus arctus* have been taken recently on our coasts. It is some years since Mr. Couch announced the first appearance of this as a British species; and none has since been recorded until these last two years, when several have been taken near Penzance by Mr. Cornish, and one off the Mewstone, near the eastern entrance of Plymouth Sound; two of these were furnished with spawn, and two were found in the stomach of a cod-fish. That which we obtained off the Mewstone was four inches and a half long, and one of the most interesting additions to our local fauna. This length is half as long again as that recorded by M. Milne-Edwards of the Mediterranean specimens.

In the dredging list published by this Association, the common lobster of Europe is called *Astacus gammarus* (L.), *marinus* (Fabr.), and *Homarus vulgaris* (M.-Edwards). But since the descriptions of Linnæus of crustacea are so very general, and the specific name used by him has been long closely associated with that of a very distinct genus, we think that of Fabricius (the next in succession) should be adopted. Again, the generic name given by Fabricius, *Astacus*, although prior to all others, yet included the freshwater genus, with which it is so closely associated that it would be inconvenient to make an exchange. We therefore propose, in accordance with the rules laid down by this Association, to retain the generic name of M. M.-Edwards and the specific name of Fabricius, and call it *Homarus marinus* (Fabr.).

We cannot turn away from this species without noticing the manner in which the process of repair is carried on in the development of a new flagellum to the inferior pair of antenna. Mr. Lloyd, Conservator of the Marine Zoological Collection at Hamburg, to whom the reporter is indebted for the preparation from which fig. 4 in Plate III. is taken, writes to us, "The animal lost the antenna by accident, just where the juncture with the peduncle takes place; and then the antenna began to grow in a spiral case, the spiral growing larger and increasing the number of its turns as it grew older, but never getting hard or coloured. When the entire exuviation of the lobster took place (in about four months after the antenna was broken off), the antenna was drawn out of its special case and came forth straight, the spiral skin retaining its shape. Hardening of the antenna does not take place (or at least it does not appear hard) till after exuviation; and in like manner the limbs of all the lobsters here which renew their limbs."

A specimen of the genus *Axius* was taken by Mr. Couch off Polperro, and described by him as new in the 'Zoologist,' pp. 52–82, 1856; but we are not aware that it has been since met with.

We have taken what we believe to be specimens of *Crangon fasciatus* and *Cr. sculptus*; and a careful comparison of them with the descriptions and figures of the authors has failed to convince us that they are not more or less spinous varieties of the same species; and in character they agree so well with the description of *Crangon boreas* (Phipps) that it is difficult to believe that they are not depauperized specimens of that large arctic species.

Several specimens of *Alpheus ruber* have been taken on shelly ground off the Dodman, and from the same locality two other specimens of *A. edwardsii*, (Pl. III. fig. 2)—which we believe is the first time that this latter species has been recorded as British. We had them alive for several days. Their colour is a brilliant crimson red, *A. ruber* being rather paler and more banded than *A. edwardsii*. One peculiar and interesting feature in the structure of this animal is the alteration of the character of that portion of the carapace that covers and protects the organs of vision; this, which is due not so much to the anterior development of the carapace as it is to the eyes having receded beneath it, is so changed that, while it offers protection to the organs of vision, yet it has become so transparent that it is only by close and careful examination that, in the living state, the relation of the two parts to each other can be distinguished.

The next genus to which we have to allude is one that is new to our fauna. It was first described under the name of *Typton* by Costa, from species taken at Naples as far back as 1844 (Annali dell' Acad. degli Aspir. Nat. di Nap. ii.), by Grube (Ein Ausflug nach Triest und dem Quarnero, pp. 65 and 125), and in 1856 by Heller under the name of *Pontonella* (Verhandlungen des zool.-bot. Vereins in Wien, p. 627, Tafel ix. figs. 1–15).

The British species differs in several points of detail from the figure of the Mediterranean species given by Heller in his 'Crustaceen des südlichen Europa.' We have therefore considered it a distinct species, and have named it

Typton spongiosum, of which the following is a short description:—

GEN. CHAR.—Carapace short and deep, covering the entire pereion. Pleon twice as long as the carapace, with the lateral walls deep. Eyes prominent, not concealed under the carapace, superior antenna having a secondary branch. First pair of pereiopoda equal, slender, long, and chelate. Second pair large, in general the right much larger than the left.

SPEC. CHAR.—Carapace having a short, simple rostrum. Eye longer than the rostrum. Anterior antennæ with the secondary appendage longer than the primary; posterior antennæ having the squamiform plate of the third joint

small, pointed, and not ciliated. Second pair of pereiopoda having the propodos as long and nearly as broad as the carapace. Dactylos of the right hand with the cutting margin convex and simple, on the left hand less convex and cuneated. Posterior pair of pleopoda with the posterior external angle of the outer ramus dentated, the inner tooth being the longest. Telson armed with four lateral dorsal spines, and tipped with a few spines and hairs.

We have taken several specimens of *Nika*; and from their general resemblance to *N. couchii*, while possessing the channelled telson of *N. edulis*, so particularly pointed out by Bell as a specific distinctive test, we are much inclined to believe that there is but a single British species yet known, and that *N. couchii* is but a variety of *N. edulis*, Risso. An examination of its parts in detail has shown us that the mandibula (Pl. III. fig. 3) is formed on a plan that nearer associates the genus with that of *Crangon* than with *Alpheus*, in the family of which, the latter being the type (ALPHEIDÆ), *Nika* is placed by M.-Edwards and Bell, while Dana, more correctly we think, has placed it in a subfamily of the CRANGONIDÆ, the LYSMATINÆ.

Two or three specimens of *Athanas nitescens* have been taken off Polperro.

Hippolyte barleei, which was described by us from a Shetland specimen several years ago, must, we think, be expunged from the list of species, since, as pointed out by the Rev. A. M. Norman some time since, it is only an accidental variety of *H. cranchii*. Our observations of the *Stomapoda* have been limited to a few of the commoner species; whether this arises from the species not being abundant on our southern shores as compared with those on the northern, or from accidental causes, attributable to our collecting-arrangements, is yet to be determined.

Amongst the smaller crustacea there is little to which we should wish to draw special attention, except that we have recently taken what may prove to be an undescribed *Anthura*, and to some observations on the structure of *Tanais*.

In 1861 Van Beneden asserted that the proper place of the genus *Tanais* was near to that of the family of the *Diastylidæ*, because the cephalon was developed upon the type of the carapace of the Decapoda. In 1864 this opinion was followed by Dr. Fritz Muller, who stated that though he had been unable to identify branchial appendages, yet he felt assured that it possessed rudimentary organs, because he had observed a current of water playing from beneath the carapace. Recently having obtained some living specimens, we have been able to support Dr. Fritz Müller's conclusion relative to the current of water; for by the assistance of transmitted light we have been able through the walls of the carapace to see the branchial appendage waving to and fro; we have since dissected out the organ, a drawing of which accompanies this Report (Plate III. fig. 5, *h*).

ECHINODERMATA.—Mr. Couch, reporting on the Echinodermata, says:—We have taken *Echinus sphæra*, *E. miliaris*, *Echinocyamus pusillus*, *Spatangus purpureus*, *Amphidotus roseus*, small examples of *Palmipes membranaceus*, *Asterias aurantiaca*, *A. glacialis*, *Porania pulvillea* (by far the most beautiful, in splendour and variety of colour, of all our native starfishes, and also the scarcest; the colours are liable to variation in different individuals), *Luidia fragilissima*, *Ophiocoma filiformis*.

There was a time when the flexible species of corals were in abundance on the rather hard and what fishermen, from its being free from large stones and rocks, term clean ground; but this for the most part has been swept doubly clean by trawling; and the shelter of these corals and the lower animals which grew among them, which invited fish to seek it for spawning, and also afforded refuge especially to the young fish, is destroyed, on which account very little of these corals was seen. From a fisherman's hook, how-

ever, in rather shallower water, was obtained a large example of the species named, in the Journal of the Zoological Society, by Dr. J. E. Gray, *Rhodophyton couchii*, the second that has been met with, more fleshy than the former, and now also deposited in the British Museum. An incrusting *Alcyonium* was also found, which took the form, in its contorted windings, of the slender substance that passed through and supported it. Added to these, we dredged up *Cellepora ramulosa*, and what I believed to be *C. lævigata*; but having sent the specimen to our lamented friend the late Joseph Alder, he hesitated to decide regarding it.

Sponges.—The sponges were not the least interesting of the objects that we have obtained—and so much the rather as our observations on them have had the advantage of the assistance of Dr. Bowerbank, to whom specimens of all were submitted for his opinion. Among the sponges examined by Dr. Bowerbank, we have to congratulate ourselves on the acquisition of two which that naturalist pronounces new to science and the first as such which he has seen since the publication of his Treatise on this department of Natural History by the Ray Society.

These examples, of course, remain with Dr. Bowerbank, who has done Mr. Couch the honour to name the first of them *Halichondria couchii*. Of these we annex the author's descriptions.

"*Halichondria couchii*, Bowerbank.—Sponge massive, compressed, sessile. Surface even. Oscula simple, dispersed, minute. Pores inconspicuous. Dermal membrane pellucid, spiculous, reticulated; spicula of the rete same as those of the skeleton; tension specula acerate, minute, and very slender, few in number; retentive spicula simple and contort bihamate, minute and slender, not very numerous. Skeleton:—Reticulations regular and distinct; rete rarely more than unispiculous; spicula acerate, rather stout. Interstitial membranes pellucid, spiculous; tension and retentive spicula same as those of the dermal membrane.

"Colour. Dried, light grey.

"Habitat. Coast of Cornwall, Mr. Jonathan Couch.

"Examined in the dried state."

The next novelty was observed to bear a resemblance to the rare *Microciona fictitia*, but on dissection, with the aid of a microscope, it also showed itself to be new, and it is accordingly named *M. fraudator*:—

"*Microciona fraudator*, Bowerbank.—Sponge massive, sessile, parasitic on Fuci or Zoophytes. Surface uneven, pustulous. Oscula simple, dispersed. Pores inconspicuous. Dermal membrane abundantly spiculous; tension spicula same as those of the skeleton, irregularly fasciculated or dispersed; fasciculi broad and flat, multispiculous; retentive spicula bidentate, equianchorate, minute, not very numerous. Skeleton:—Columns diffuse, long, and very irregular; spicula fusiformi-acerate, short and stout. Internal defensive spicula attenuato-acuate, variable in length, very nnmerous, rather stout; tension spicula same as those of the skeleton, intermixed with internal defensive spicula; retentive spicula same as those of the dermal membrane.

"Colour. Dried, brown, with a tint of yellow.

"Habitat. Polperro, Mr. Jonathan Couch.

"Examined in the dried state."

Halichondria panicea, a large specimen; *H. albescens*, Johnston; *Hymeniacidon albescens*, Bowerbank; *H. simulans*, Johnston; *Isodictya simulans*, Bowerbank.

Halichondria suberea.—In a ball of this I found shut up, but with an orifice, the crustacean *Pagurus cuanensis*; and in one or two similar balls there

were other hermit crabs; but in these instances there was not a shell on which the sponge had incrusted itself. I can scarcely imagine how a shell can have disappeared after having been thus incrusted; and it is difficult also to imagine how, without a solid support, this sponge could have formed itself into a ball round the crab (which had a defined cavity within) as we find it to have done*.

H. incrustans, covering the carapace and legs in patches, of a species of spider crab.

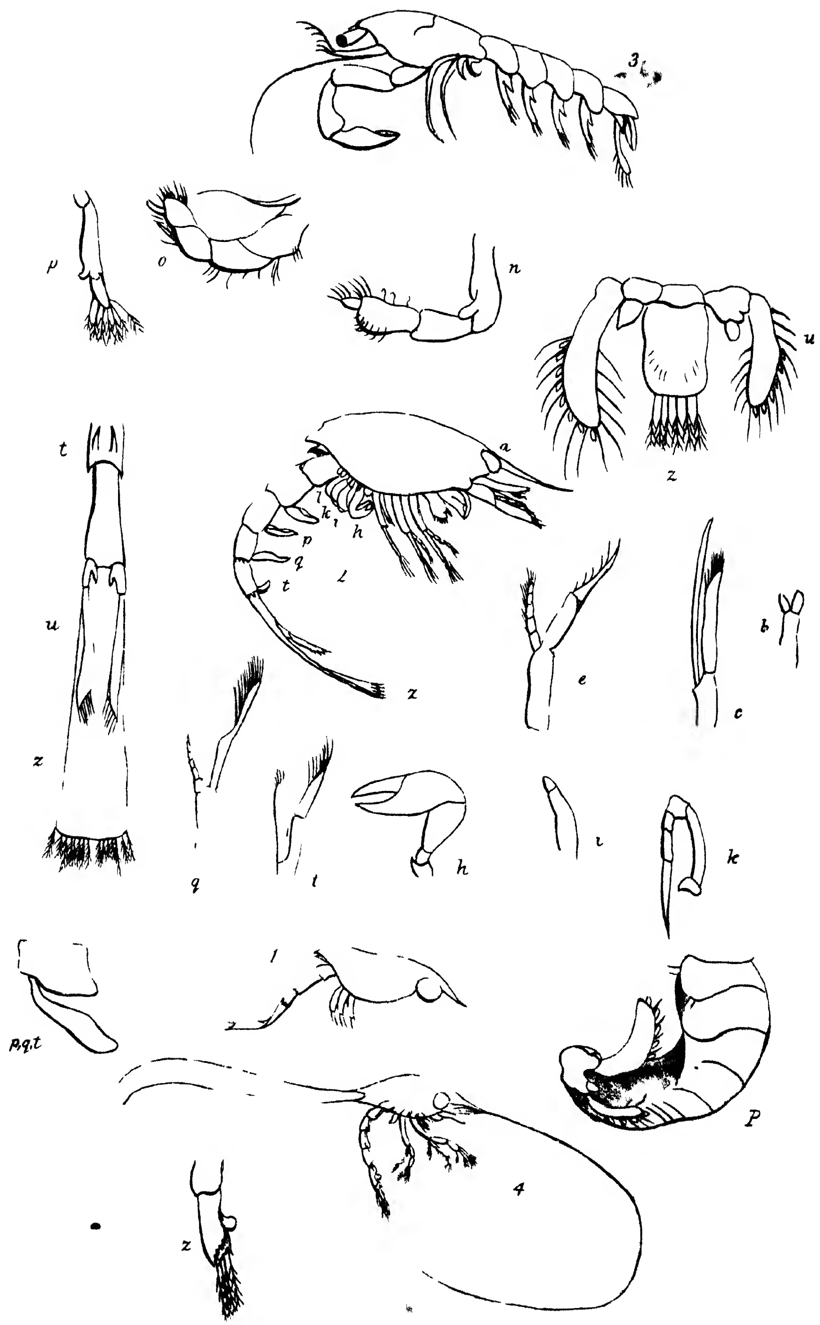
Hispida dictyocylindrus, H. Bowerbank.—There is something remarkable in the circumstances which have attended the dredging of this species, and which I can explain only by supposing that two species are confounded together, which on the other hand I am assured, on high authority, is not the case. Thus, in spaces or districts at the depth of about twenty, and again in forty fathoms, there came up examples of this slender, branched sponge, measuring, some of them, a foot in length, with the surface truly hirsute, and which had been fixed to the ground by a well-marked and rather broad root. But at other places and in deeper water, there clearly had never been, of any one of the many examples obtained, an attachment to the ground; and the branching growth proceeded from both ends, with an intermediate space, not always in the middle, of from one to two or three inches in length, and which appeared to be that middle line or stem from which the branches at each end derived support, but which had not even a slight mark of a root or point of attachment. Secondary branches are at least rare, if they occur at all in this (variety); and its surface has a much finer grain than is common on the rooted examples. Some of these specimens at least appear to have lain along the ground; but in a single instance one of the ends must have been erect, since on it was growing, parallel with it, a flexible coral and two examples of *Pollicipes scalpellum*. In one instance also a fine specimen of *Grantia ciliata* had become fixed on a prostrate branch; and of another, of small size, now in the possession of Dr. Bowerbank, with three branches at each end of a short middle stem, it was the opinion of that gentleman that two examples had been brought into contact with each other and had thus become united; but on examination I was not able to discern any such mark of union, and of a root or footstalk there was no appearance.

Other species of sponge obtained in these dredgings are:—*Halichondria ficus*, named by my late friend Joshua Alder, from sixty fathoms; *Desmacidon fruticosa*, Bowerbank; *Hymeniacidon virgultosa*, Bowerb., near the land at Lantwit Bay; *Dysidea fragilis*, Johnston; *Grantia compressa*; *G. fistulosa*, Johnst.; *Leuconia fistulosa*, Bowerb.; *G. ciliata*; *G. lacunosa*, Johnst.; *Leucosolenia*, Bowerb., in shallow water, on the carapace of the Corwich crab; *Amouracium proliferum* and *A. læve*, from rocks in Lantwit Bay.

Of a large abundance of Annelids we are not able to give an account, but they have been placed in safe hands, examples having been sent to the Reporter† and to the British Museum. What appear to be three species of *Aphrodyte* have afforded me figures. *Polynoë squamata*, *Ocnus brunneus*, and two or three species of *Sipunculus* derive their interest in our labours from a knowledge of the depth of water and distance from land in which they live.

* [The sponge is first formed on the shell, which is afterwards destroyed by the sponge, by the same power that enable sponges to bore into shells.—Reporter.]

† These are sent to Dr. Mackintosh for examination, and will be described in our next Report.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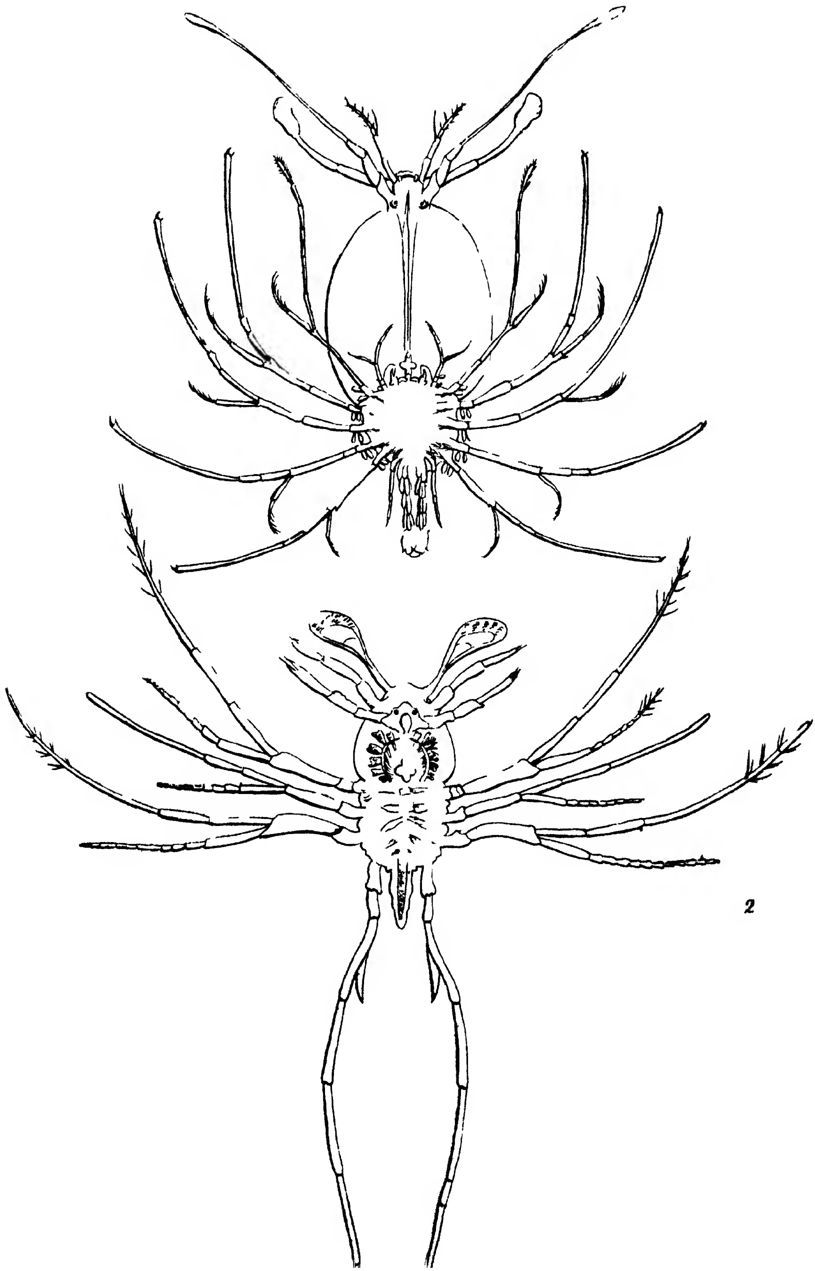

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PLATE I. Development of *Pagurus*.

Fig. 1. First stage*.

Fig. 2. Second stage. The author gives this with the reservation stated, having taken it swimming in the open sea. c. Dorsal view of cephalon. *a*. Eye. *b*. Sup. ant. *c*. Inf. ant. *d*. Mandible. *g*. Posterior maxilliped. *h*. First pair of gnathopoda. *i*. Second pair. *k*. First pair of pereiopoda. *l*, *m*, *n*, *o*. Four posterior pairs of pereiopoda. *p*, *q*, *t*. Pleopoda. *u*. Sixth pair of pleopoda, z. Telson.

Fig. 3. Third stage, representing the genus *Glaucothoe* of Milne-Edwards and *Protophylax* of Latreille. *n*. Penultimate pair of pereiopoda. *o*. Ultimate pair of pereiopoda. *p*. A pleopod. *u*. Sixth, or posterior pair of pleopoda. z. Telson. P. Pleon of an older specimen.

Fig. 4. Zoë of *Porcellana platycheles*. z. Telson.

PLATE II.

Fig. 1. *Phyllosoma*. Fig. 2. Zoë of *Palinurus marinus*.

PLATE III.

Fig. 1. *Typton spongiosum*, new species. References as above.

Fig. 2. *Alpheus edwardsii*. Fig. 3. *Nika edulis*.

Fig. 4. *Homarus marinus*. Development of flagellum to lower antenna.

Fig. 5. *Tanais*. *h*. First pair of gnathopoda, with branchial appendage attached.

Supplement to a Report on the Extinct Didine Birds of the Mascarene Islands. *By* ALFRED NEWTON, *M.A., F.L.S., Professor of Zoology in the University of Cambridge.*

IN 1865, at Birmingham, a Committee was appointed to assist the author's brother, Mr. Edward Newton, Auditor General of Mauritius, in his researches into the Didine Birds of the Mascarene Islands. Last year, at Nottingham, the Committee reported; but their Report, printed in the Annual Volume of the Association for 1866 (p. 401), was in one respect very unsatisfactory; it could only speak of promise, not of performance. Indeed almost the sole feat it could recount was the having drawn the money granted. The powers of the Committee, however, being now ended, the only thing left was to show that they had been properly applied, and this was best done by exhibiting a selection from the large series of bones of the Didine Birds of the island of Rodriguez, which had been collected by labourers sent expressly to that island by Mr. Edward Newton in the autumn of 1866, as stated in the Report of the Committee. It had been formerly shown by the late lamented Hugh Edwin Strickland (The Dodo and its Kindred, p. 46) that this bird, *Pezophaps solitaria* (Gmel.), was Didine in its affinities, though generically separable from the true Dodo, *Didus ineptus*, Linn. This conclusion, though originally arrived at on very slight evidence, was now shown to be completely correct, and the establishment of the genus *Pezophaps* is proved to have been fully justified by the examination of the almost complete series of bones obtained by Mr. Edward Newton. On some of the peculiarities presented by these bones the author dwelt slightly, but in particular on an unexpected confirmation of the evidence of Leguat, by the discovery of an extraordinary bony knob near the extremity of the wing. Leguat, whose account† of the habits of the Solitaire was the only one we possessed, mentioned that "l'os de l'aileron grossit à l'extrémité, et forme sous la plume une petite masse ronde comme une balle de mousquet." Now the existence of this "masse ronde" was proved by the bony knobs attached to several metacarpal bones exhibited; and thus the veracity of Leguat was established on this point, as it had been on so many others. In conclusion, the author stated that at present we know little more of the Didine Bird of the Island of Réunion than that it was nearly *white*. In the course of last year Mr. Tegetmeier had shown him an old

* This was taken so young from the ovum that the reporter is not certain whether the long projecting rostrum is a feature or not, as at this period it is generally folded under.

† Voyage et Avantures de François Leguat, &c. (Londres: 1708. 2 vols. 12mo), vol. i. p. 98.

water-colour painting of a nearly *white* Dodo, which he was inclined to believe might represent this lost species; but he trusted that the French naturalists in that island would succeed in obtaining actual relics of it.

Report on Observations of Luminous Meteors, 1866–67. *By a Committee, consisting of* James Glaisher, *F.R.S., of the Royal Observatory, Greenwich, President of the Royal Microscopical and Meteorological Societies,* Robert P. Greg, *F.G.S.,* E. W. Brayley, *F.R.S.,* Alexander S. Herschel, *F.R.A.S., and* Charles Brooke, *F.R.S., Secretary to the Meteorological Society.*

The object of collecting observations of Luminous Meteors to serve as a basis of reference for calculations, and pointing out whatever conclusions may be drawn from them, is kept in view by the Committee, in presenting with this Report a continuation of the Catalogue of former years.

The apparent places of the meteors are given either (most conveniently) by their right ascensions (α) and declinations (δ, + north, and − south), by the well-known method of their allineations with certain neighbouring stars, or (in some cases of, generally speaking, less accurate approximations) by their apparent azimuths and altitudes with respect to the visible horizon.

A large proportion of the descriptions contained in the present Catalogue refer to great meteors recorded on the morning of the 14th of November, 1866. A long list of meteors of a less striking description than those selected for entry in the Catalogue, noted on the same morning, was received by the Committee from observers, whose reports on the particular phenomena of the shower are noticed, with more or less detail, in the fourth Appendix of the Catalogue.

The greatest multitude of the meteors on the morning of the 14th of November made their appearance exactly during the hour from one to two o'clock A.M., which was the hour appointed beforehand by the Committee, with a view to secure the cooperation of observers, for making simultaneous observations of the shower.

One meteor during the hour was simultaneously recorded at Sidmouth, at Cardiff, and at Stretton, Hereford; and the length of the terminal portion of its phosphorescent streak, which remained visible for ten minutes, was found to be eighteen miles (Appendix I.).

The heights of three other meteors of the November shower were satisfactorily found. One, which left a remarkably persistent luminous streak over the town of Dundee, was from 51 to 57 miles above the earth's surface.

One meteor also, on the 10th of August last, was simultaneously observed at London and at Birmingham. This disappeared at a height of 76 miles above the neighbourhood of Bristol.

The supposed region of the true radiant-point of many of the individual meteors in the Catalogue is indicated by the observers. Excellent means are thus afforded for distinguishing the obvious peculiarities of light and motion which characterize meteors from particular radiant-points. To assist observers in this inquiry, all the observations hitherto entered in the Catalogue are mapped on a series of charts, the first four maps of which series are now lithographed, and 25 impressions are presented to the British Association with this Report.

The position of each radiant-point amongst the constellations is conspicuously entered upon the maps, with its annual dates of maximum, and dura-

tion; and upon the same chart the meteor-tracks proceeding from the particular radiant-point are denoted by such plain signs as to indicate directly the particular radiant-point with which they are connected.

In the case of the best-established star-showers, the meteor-tracks engraved upon the maps will generally be found to tell beforehand the course which meteors appearing at any part of the sky from one of those radiant-points will pursue across the sky, like wires stretched for the meteors to run upon (to use the words of one observer of the November shower last year).

In other cases, where the position of the radiant-point is not yet so well established, its printed place must be regarded as provisional and as requiring further confirmation by observations to decide its real place. A copy of one of the first four maps exhibited, showing the radiant-point of the November meteors, as observed at the Royal Observatory, Greenwich, will be found in the fourth Appendix of the Catalogue. The three other plates refer to the special radiant-points in January, August, and October. The whole series will be in readiness to distribute to observers this year before the reappearance, as anticipated, of the great star-shower on the morning of the 14th of November next.

If the space of the Committee has been taxed to secure insertion in the Catalogue for the multitudinous observations of meteors of the 14th of November last*, it is much more difficult to represent adequately more than twenty French, and about as many German descriptions of a large detonating fireball seen by daylight in the north of France on the 11th of June last, which the Committee have received. The luminous streak left by the meteor was visible, at many places, for more than an hour after the first appearance of the meteor, and exhibited unusual contortions. Its occurrence very near the date of the 9th of June, marked last year by the prodigious stonefall of Knyahinya, and in the present year by the fall of three aërolites at Tadjera, in Algeria, is pointed out, in Appendix II. and III., as probably connecting these three extraordinary occurrences together in a single aërolitic period.

At the end of the Report is placed an addition to the Catalogue of large meteors and aërolites, by Mr. R. P. Greg, in continuation of that printed in the volume of Reports for the year 1860; supplying the omissions, and bringing up the date of that Catalogue to the present time. It will, it is believed, be found a perfect repertory of this kind of meteoric occurrences, for the possession of which the British Association will congratulate itself.

Abstracts of a number of important papers on the subject of shower-meteors are deferred until a time when the maximum display of the November star-shower will probably have been observed in America in November, 1867, and the spectacle, in that case, will probably give rise to a new discussion on the subjects of which they treat. Some recent papers by M. Daubrée, on the synthesis and classification of meteorites, will also then be reviewed.

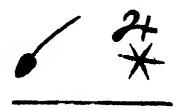
Approaching hours of daylight will probably deprive observers in the British Isles of all participation in the specially interesting display of the November meteors in the current year, although the stage of the gradual commencement of the shower will be better observed in England than in America. It was thus that the August meteors, this year, were nearly invisible, from the hours of daylight appearing in England; but according to an American account contained in Appendix IV., they were visible there "in countless numbers" soon after midnight, on the night of the 10th of August last.

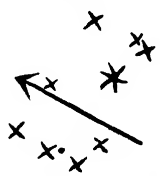
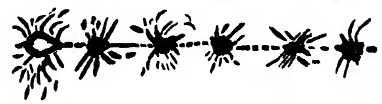
* The Greenwich observations of meteors which hitherto have appeared in these Catalogues, will in future be printed in the volumes of the Greenwich Magnetical and Meteorological Observations for their respective years.

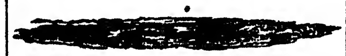
A CATALOGUE OF OBSERVATIONS OF LUMINOUS METEORS.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1857. June 1	h m 9 15 p.m. local time.	Hobart Town, Van Diemen's Land.	Twice as bright as Jupiter.	Red colour ...	About 2 secs...	Between α and β Capricorni.	....	Stationary object.	....	....	'Twenty-five years' Meteorological Observations at Hobart Town,' F. Abbott, p. 13.
Sept. 22	5 10 a.m. local time.	Ibid	= ♃	Faint white ...	2 seconds ...	From Mira (ο Ceti) to β Ceti.	Left no train	....	....	Train not visible, because of the commencement of twilight perhaps.	Id., p. 14.
1858. Apr. 24	8 10 p.m. local time.	Ibid	One-third diameter of moon; 10′ diameter; well defined disk.	Pale white, inclining to blue.	4 seconds......	From δ Canis Majoris to α Hydri.	Left a train 8° in length...	....	....	Seen by several persons	Id., p. 16.
May 24	5 5 p.m. local time.	Ibid	Equal Mars in intensity. A disk about one-tenth diameter of the moon.	Pale white ...	7 seconds......	From ε Sagittarii to β Scorpii.	Left a train of yellowish colour 4° in length.	....	....	....	Id.
Sept. 3	4 10 a.m. local time.	Ibid	= ♃	White	2 seconds ...	From β Canis Majoris to γ Eridani.	Left a train 3° in length...	....	....	....	Id., p. 17.
1862. Apr. 25	8 20 p.m. local time.	Ibid	Estimated diameter 15′.	....	4 seconds......	From ν Centauri to Nebula Major.	Left a long train of sparks for ten minutes, which gradually contracted itself into an oblong form from 1° to 2° in diameter, and for a time appeared to station itself a little to the west of γ Crucis.	60°	....	The meteor gave a brilliant illumination, much more incandescent than that produced by the full moon.	Id.
1864. July 13	10 15 p.m. local time.	Boston, Mass., U. S. A.	As bright as Vega Lyræ appears in a telescope of low power.	....	....	Commenced near ε Delphini. Passed 2° or 3° below ε and θ Pegasi.	At first tailless, but shortly afterwards left train 3° or 4° long which was cigar-shaped, apparently consisting of condensed particles, and remained visible 3 seconds; from ε to θ Pegasi.	....	....	Seen also at Hartford, 100 miles S.W. from Boston.	James Gardner, Am. Jour. Sci., 2nd Ser., vol. xxviii. p. 295.
1865. June 10	11 48 p.m.	Weston-super-Mare.	=1st mag.*	White	1 second	α= δ= From 318°+47° to 314+39	....	....	....	....	W. H. Wood.
10	11 55 p.m.	Ibid	= ♃	White	1 second	From 72+55 to 80+46	....	....	....	Sky clear; full moon ...	Id.
18	1 17 a.m.	Ibid	=1st mag.*	Yellow	1 second	From 225+13 to 209+10	....	....	....	....	Id.
19	11 30 p.m.	Ibid	=3rd mag.*	Blue	1 second	From 250 − 3 to 218 − 15	....	....	....	....	Id.
21	10 55 p.m.	Ibid	Brighter than a 1st mag.*	Yellow	1 second	From 230 + 28 to 210 + 20	....	....	....	Principal Radiant during this month, W.	Id.

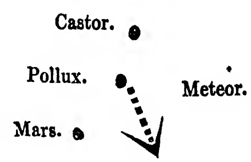
Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1865. June 21	h m 11 0 p.m.	Weston-super-Mare.	=3rd mag.*	Blue	0·5 second	$\alpha=$ $\delta=$ From 260°+27° to 270+20	......	......	......	......	W. H. Wood.
21	11 0 p.m.	Ibid	=3rd mag.*	Blue	0·5 second	From 260+27 to 257+34	......	......	......	......	Id.
21	12 0 p.m.	Ibid	=2nd mag.*	Blue	......	From 218+30 to 211+20	......	......	......	......	Id.
22	0 45 a.m.	Ibid	Brighter than a 1st mag.*	White	0·25 second	From 317+70 to 0+90	Left an irregular phosphorescent patch about 14′ diameter near the centre of its path, which remained visible 3 or 4 seconds.	......	......	......	Id.
22	11 0 p.m.	Ibid	=1st mag.*	White	0·75 second	From 70+60 to 77+50	......	......	......	......	Id.
26	11 30 p.m.	Ibid	=1st mag.*	White	1 second	From 218+28 to 190+41	......	......	......	......	Id.
27	0 40 a.m.	Ibid	=1st mag.*	White	0·5 second	From 346+23 to 6+29	......	......	......	......	Id.
28	12 0 p.m.	Ibid	=2nd mag.*	Blue.	0·75 second	From 32+48 to 50+49	......	......	......	......	Id.
1866. Feb. 2	10 50 p.m.	West Peckham, Maidstone.	Very brilliant meteor.	Bluish, changing to red.	Scarcely a sec.	About 5° above the horizon, a little east of south.	It burst with very greatly increased brilliancy, but without any fragments, and disappeared.	Almost stationary.	Rather ascending, and then slightly falling.	View in the south-east direction uninterrupted; no sound heard.	Ernest Jones.
Mar. 13	10 39 p.m.	Hawkhurst (Kent).	=1st mag.*, then =2nd mag.*	White, then red.	2·5 seconds	From ½(ζ, 78) two-thirds of the way to z Virginis.	In the first half (a, b) of its course, bright white. Then diminished, and changed to red, drawing a train of red sparks, and disappearing with a flash at c.	......	...... 	Two meteors seen in 20 minutes: clear sky; no moon; one observer.	A. S Herschel.
May 14	9 55 p.m.	Manchester	=1½ mag.*	Bright white	½ second	Close to β Aurigæ	......	1°	Directed from Polaris	......	R. P. Greg.
July 22	11 11 p.m.	Hawkhurst (Kent).	=2nd mag.*	White	1·5 sec.; very swift.	From ⅓ (φ, V_2) Herculis to γ Serpentis.	Left a streak on its whole course for 1½ second.	30°	Directed from Perseus	......	A. S. Herschel.
22	11 40 p.m.	Ibid	=2nd mag.*	Yellow	1·3 sec.; moderate speed.	From *f* Pegasi to ½ (γ, η) Cygni.	Left no train or sparks. Disappeared gradually.	15°	Last half of course decidedly serpentine. 	Seven meteors in one hour: clear sky; no moon; one observer.	Id.
Aug. 6	9 15 p.m.	Ibid	=3rd mag.*	White	0·5 second	From κ Cephei to χ Draconis.	No train or sparks	......	......	Six meteors seen in 45 minutes: beautifully clear sky; no moon; one observer.	Id.
Sept. 24	10 to 11 p.m.	Birmingham	......	......	......	......	......		......	Clear fine night. In one hour no meteors seen. On the nights of the 25th and 26th sky overcast.	W. H. Wood.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Oct. 14	h m 7 28 p.m.	West Hendon, Sunderland.	=2nd mag.*		Moved slowly	From near ζ to 2° below ε Pegasi.			Horizontally to the right		T. W. Backhouse.
14	9 3 p.m.	Ibid	=2nd mag.*	Yellow	Rapid	Disappeared at a point about α = 180°, δ = +78°.					Id.
15	6 34 p.m.	Ibid	=Sirius	Orange colour	Moved slowly	Went behind a cloud about 10° preceding η Boötis.			35° to the left of perpendicular; down.		Id.
16	8 58 p.m.	Hawkhurst (Kent).	=2nd mag.*	Yellow	1 second	From τ Cephei to φ Draconis.	Brightest near the middle of its path.			Two meteors seen in forty-five minutes: clear sky; quarter-moon.	A. S. Herschel.
19	About 3 a.m.	At sea, on the passage between Dover and Holyhead.	5′ or 6′ in diameter. Most brilliant.	Violet, approaching to scarlet.		Appeared at an altitude of about 70°.	Left a train for five minutes by the watch, which changed its form from a straight line to two straight lines, making an obtuse angle thus—  and then resumed its former rectilinear appearance. Sparks were projected forward by the meteor towards the direction where it disappeared.		From S. to N.	Sufficiently brilliant to illuminate the whole vessel. The attention of all on board of the steamer was drawn to it.	J. S. Davies. Communicated by A. S. Herschel.
21	8 25 p.m. (local time).	Hoboken, New Jersey, U. S. A.	Large fireball	Bright green		From near the zenith; moved towards the S.W.; disappearing over Jersey city.	Burst without noise into a thousand brilliant green fragments, leaving a bright green train, which, like the head, broke into a perfect rain of emerald-green-coloured fragments.			A curious circumstance was its stationary appearance at first, and its rapidly increasing velocity afterwards; the brilliant emerald colour of the meteor, and of the fragments.	Ernest Turner, 'Scientific American,' Nov. 17th.
24	4 40 p.m.	The Curragh, Kildare, Ireland.	Much brighter than the planets.		Fell slowly	From about R. A. 335°, N. Decl. 3°, to about R. A. 358°, S. Decl. 5°. Rough positions from a drawing.	Like a piece of lighted paper falling.	About 40°	 Horizon.	Seen in twilight; two stars only visible.	Communicated by A. S. Herschel.
28	7 50 p.m.	York	=3rd mag.*	Yellow	½ second	Near α Ursæ Majoris.					J. E. Clark.
28	7 54 p.m.	Ibid	=1st mag.*	Yellow	⅓ second	From δ Cygni to Equuleus.					S. Thomson.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Oct. 28	h m 7 58 p.m.	Ibid	=1st mag.*.........	Yellow	½ second	From cluster in Perseus to Great Nebula in Andromeda.	....	23°	From γ Leonis	....	J. E. Clark.
28	8 1 p.m.	Ibid	=1st mag.*.........	Yellow	½ second	From β Aurigæ to Pleiades.	....	24°	....	....	Id.
28	8 6 p.m.	Ibid	=2½ mag.*	Yellow	½ second	From γ Cassiopeiæ to χ Persei.	....	17°	....	Four or five other meteors seen with the above.	Id.
30	10 29 p.m.	West Hendon, Sunderland.	=3rd mag.*	Orange colour	....	Disappeared near 30 Aquarii.	....	4°...........	Directed from ϵ Pegasi	....	T. W. Backhouse.
31	10 30 p.m.	Chesham (Bucks)	Telescopic	Very red	Momentary ...	Crossed the Pleiades west of Alcyone. 	Left no train	....	....	Darted across the field of view of the telescope like a red star of the 5th magnitude; very slightly woolly at the edges.	C. Grover.
Nov. 1	8 40 p.m.	West Hendon, Sunderland.	=2nd mag.*	Yellow	....	Disappeared at α=220°, δ=+50°.	....	....	20° to the left of perpendicular, down.	....	T. W. Backhouse.
3	6 58 p.m.	Primrose Hill ...	=4th mag.*, then twice as bright as ♃.	Vivid blue	2 seconds......	α= δ= From 63°+50° to 185+69	Left a long scarlet streak on its whole course for 5 seconds, which became separated from the nucleus just before final disappearance.	40° or more	From Radiant, ξ Persei..	The nucleus threw off a few sparks, and became quite detached from the train.	T. Crumplen.
3	10 16 p.m.	Ibid	Twice as bright as ♃.	Blue	....	Began ½° to left of α Arietis.	Ended with a brilliant flash. Left a train on the whole length of its path, which faded suddenly.	10°	Directed from Aldebaran.	Imperfect view	Id.
6	5 55 p.m.	Ewhurst (Sussex).	About three times as bright as Venus.	....	7 or 8 seconds, motion unusually slow.	From near Venus to Ursa Major, disappearing beneath β of that constellation. [Position of Venus α = 262°·5, δ=−28°.]	From its slow motion, the eye could easily see a process of combustion like that of ignited iron wire in a nearly exhausted vessel of oxygen gas. 	....	....	Stars faintly visible. Hazy vapour in the sky. There was no continuous train, but sparks were thrown off which died away immediately. Its more vivid phases are represented in the sketch.	H. P. Harrison.
6	6 30 p.m.	York	=3rd mag.*	Yellow	½ second	From χ Persei to μ Andromedæ.	....	14°	....	....	J. E. Clark.
6	6 59 p.m.	Wimbledon (Surrey).	Apparent diameter and brightness of ♃.	....	3 seconds in half its path.	From 8° north-west of Capella to 4° north and 4° west of α Ursæ Majoris.	Separated just before vanishing into several heads.	....	....	No detonation audible...	F. C. Penrose.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Nov. 6	h m 11 30 p.m.	Wisbeach (Cambridgeshire).	Brighter than Venus	Bright blue ...	....	From Taurus to Cetus.	Burst and fell in sparks like liquid drops.	....	....	....	S. H. Miller.
6	11 40 p.m.	Ibid	Nearly as bright as Venus.	Blue	About 10 secs.	Through Gemini to Taurus.	The train brightened up and ran back in this form—  widening as it shortened, and remaining several seconds.	Fully 25° ...	....	Clear sky	Id.
6	Evening ...	Carthagena, Columbia, U. S. A.	Like a ship's red light, as seen at a distance of 200 yards.	Red	Floated away steadily for 3 minutes.	At a low altitude in N.W. by W.	Like a parachute - light thrown off from a rocket. Disappeared behind houses.	....	Descending towards the N.W. by W.	The sky was cloudy and the night dark, but the light could not have had any artificial origin.	A. De G. de Fonblanque, 'The Times,' Jan. 2, 1867.
7	6 2 p.m.	York...............	=1st mag.*.........	Bright orange	¾ second	Disappeared at α Coronæ Borealis.	....	....	....	....	S. Thomson.
7	8 30 p.m.	Ibid	=3rd mag.*	Yellow	½ second	From β Aurigæ to N.E. horizon.	....	....	....	....	Id.
8	8 52 p.m.	West Hendon, Sunderland.	=3rd mag.*	....	Rapid	Passed close to μ Ceti.	....	....	Directed from ½ (Pleiades, 41 Arietis).	....	T. W. Backhouse.
8	9 16 p.m.	Ibid	=2nd mag.*	....	....	Disappeared at α=277½°, δ=+51°.	....	....	Directed from ρ Draconis.	....	Id.
9	3 41 a.m.	Ibid	=2nd mag.*	....	....	Passed midway between α and ε Leonis.	....	....	Directed from γ Leonis	Three smaller meteors this night.	Id.
9	5 5 a.m.	Glasgow	=♃	Orange yellow	2·2 seconds ...	From ɡ Lyncis to ½ (α, β) Ursæ Majoris.	Gradually increased and then gradually diminished in brightness. Left a streak for two seconds.	....	Directed from Taurus...	Nine meteors seen in one hour; two of them from Leo. A fourth part of the sky clear; no moon; one observer.	A. S. Herschel.
9	5 8 a.m.	Primrose Hill (London).	Twice as bright as Capella.	Pale blue	Swift motion..	α= δ= From 31°+62° to 8+48	Left a ruddy orange-coloured train for ten seconds.	....	From Radiant, near γ Leonis.	....	T. Crumplen.
9	5 45 a.m.	Glasgow	=3rd mag.*	White	0·4 second ...	From β Leonis to 2° over α Comæ Berenicis.	Left a streak for 2 seconds	....	Directed from Leo	Bright double auroral arch over north-west horizon on the previous evening.	A. S. Herschel.
9	7 45 p.m.	York	=2nd mag.*	Yellow	½ second	From η Aurigæ to Kochab.	....	....	....	....	J. E. Clark.
9	8 5 p.m.	Ibid	=2nd mag.*	....	¼ second	From Algol to the Pleiades.	....	....	....	....	Id.
9	8 14 p.m.	West Hendon, Sunderland.	=1st mag.*	....	....	Passed between ι and κ Pegasi.	....	....	....	....	T. W. Backhouse.
9	8 40 p.m.	Chesham (Bucks)	Far surpassed Venus at her brightest.	Bluish white...	2 or 3 seconds	First appeared at a point a little above and rather west of η Draconis.	Left no train. It increased in size and brightness, and vanished suddenly without bursting.	15°	 Fell straight downwards	It paused three times in its descent. Lit up the sky with dazzling brightness.	C. Grover.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866.	h m										
Nov. 9	10 15 p.m.	West Hendon, Sunderland.	At first small and faint, gradually increasing to a 1st mag.*	Deep yellow...	Rather slow...	From near ε Cephei towards α Cephei, disappearing 1° or 2° before reaching that star.	Drew a tapering red tail, 2° or 3° long, vanishing with the head.	....	....	One smaller meteor this evening.	T. W. Backhouse.
9	11 26 p.m.	Primrose Hill, London.	Three times as bright as α Cygni.	Pale orange colour.	....	From near η Pegasi to a point forming an equilateral triangle with ε and ζ Cygni.	The head surrounded by a large nebulous haze. Threw off many sparks.	....	....	....	T. Crumplen.
10	5 10 a.m.	Glasgow	=2nd mag.*	White	1 second	From β Geminorum to β Canis Minoris.	Hazy nucleus; left no train.	....	Course slightly undulating.	....	A. S. Herschel.
10	5 35 a.m.	Ibid	=2nd mag.*	White	1 second	From H Geminorum to γ Orionis.	Left no train	....	....	Four meteors seen in thirty minutes. Sky mostly clear. On the nights of the 10th and 11th, sky cloudy with rain and wind.	Id.
11	5 46 p.m.	West Hendon, Sunderland.	=2nd mag.*	....	....	Centre of path at ⅔ (γ Ursæ Majoris, Cor Caroli).	....	....	Directed from ε Ursæ Majoris.	....	T. W. Backhouse.
12	2 4 a.m.	Primrose Hill, London.	=2nd mag.*	Pale blue	0·7 second ...	α= δ= From 47°+ 54° to 34 + 50	Left a short train; took a sudden turn after three-fourths of its course.	8°	From Radiant, in Leo. 	Moved as if retarded in its flight; very curious.	T. Crumplen.
12	2 14 a.m.	Ibid	=1st mag.*	Vivid blue ...	0·5 second ...	From 42½ + 44½ to 14 + 30	Left a short bright train...	25°	From Radiant, near γ Leonis.	Well observed. Three meteors seen in one hour fifteen minutes. Two from Leo and one from Cassiopeia, at right angles to Milky Way. Morning hazy. Stars rather dull. Overcast at 3^h 25^m.	Id.
12	3 2 a.m.	Glasgow	=2nd mag.*	White	0·7 second ...	Commenced at ζ Ursæ Majoris.	Left a streak for 2 seconds	10°	Directed from μ Leonis.	Four meteors seen in 15 minutes: no moon; one observer.	A. S. Herschel.
12	3 5 a.m.	Ibid	=1st mag.*.........	Yellow	0·9 second ...	From α to *f* Ursæ Majoris.	Left no streak............	....	....	Sky generally clear but hazy. Afterwards overcast.	Id.
12	5 20 a.m.	Ibid	=3rd mag.*	Orange yellow	1·5 second ...	From θ Aurigæ to ½ (*g* Lyncis, Castor).	Left no streak............	....	....	Two meteors seen in fifteen minutes: sky hazy; one-third clouded, then quite overcast.	Id.
12	10 25 p.m.	West Hendon, Sunderland.	=2nd mag.*	....	....	Near 16 Draconis	....	....	....	....	T. W. Backhouse.
12	11 16 p.m.	Observatory, Aberdeen.	=3rd mag.*	....	....	From β to δ Ursæ Majoris.	....	....	....	Another, 3rd magnitude, simultaneously with it from ζ to γ Ursæ Majoris.	D. Gill.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Nov. 12	h m s 11 33 p.m.	Observatory, Aberdeen.	=3rd mag.*	......	......	From Aldebaran to within 3° of the belt of Orion.	......	......	......	From 10h to 11h p.m. six meteors seen: clear sky; five observers.	D. Gill.
12	11 39 p.m.	Ibid	=1st mag.*	......	......	From a point 2° above α to γ Geminorum.	Left a train	......	......	From 11h to 12h p.m. twenty-four meteors seen: clear sky; five observers.	Id.
12	11 50 p.m.	Ibid	......	......	......	...... 	Nebulous appearance; like a dense train without a nucleus.	......	......	The dotted line indicates the direction and length of arc.	Id.
12	11 55 p.m.	Ibid	=1st mag.*	......	......	Passed across ω Ursæ Majoris, which bisected its flight.	Left a brilliant pale green train.	......	Directed from Leo towards α Ursæ Majoris.	......	Id.
13	12 27 43 a.m.	Ibid	=1st mag.*	Greenish yellow.	2½ seconds	Crossed over α and γ Tauri.	Left a long train visible during the time of the meteor's flight.	......	From α to γ Tauri	From 12h to 1h a.m. fifteen meteors seen: clear sky; five observers.	Id.
13	12 40 33 a.m.	Ibid	=1st mag.*	......	1½ second	From ε Virginis, to a point just under β Leonis.	......	......	......	......	Id.
13	1 6 13 a.m.	Ibid	=1st mag.*	......	......	From the upper part of Leo Major to α Geminorum.	A brilliant meteor, leaving a long train.	......	......	From 1h to 1h 30m a.m. seven meteors seen; clear sky; five observers.	Id.
13	3 0 a.m.	Glasgow	=3rd mag.*	Yellow	0·5 second	Commenced at ½ (β, δ) Aurigæ.	No streak left	10°	Directed from ν Cancri.	Two meteors seen in twenty minutes; one observer.	A. S. Herschel.
13	3 2 a.m.	Ibid	=3rd mag.*	White	0·9 second	Disappeared at τ Lyncis.	Left a faint streak for half a second.	Course ⅔ of the way from Castor.	Directed from Castor	Sky one-third overcast. The rest generally clear but hazy; no moon.	Id.
13	8 37 p.m.	York	=3rd mag.*	Orange yellow	½ second	From γ Ursæ Majoris to ι Ursæ Majoris.	......	20°	Inclining 75° 	......	S. Thomson.
13	8 40 p.m.	Ibid	=2nd mag.*	Red	1·5 second	From Delphinus to α Aquilæ.	Left a short train which lasted a quarter of a second; burst at last.	12½°	...... 	......	Id.
13	9 30 p.m.	Bracondale, Norwich.	Splendid meteor	......	......	......	......	......	From nearly E. to W.	......	J. Crompton.

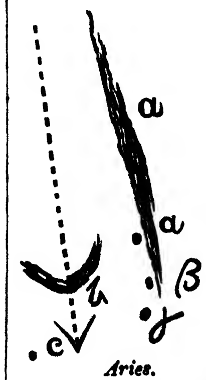
Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Nov. 13	h m s 11 8 p.m.	Primrose Hill, London.	=4th mag.*, then 2× ♀	Pale blue ...	1·5 second ...	From ½ (α, β) Geminorum. Passed between (α, γ) Orionis to μ Eridani and 5° beyond.	Left a superb streak of scarlet about 50° long.	......	......	......	T. Crumplen.
13	11 15 p.m.	Newcastle-on-Tyne.	Splendid meteor...	......	......	Swept across Orion, disappearing near Cetus.	Left behind it a long train of blue light.	......	......	......	'Newcastle Chronicle,' Nov. 15th.
13	11 22 p.m.	Haddenham, (Bucks).	Brighter than Mars or Sirius. Nearly equal Venus.	Pinkish	......	Passed a little south of Rigel, and became extinguished at an altitude of 25°.	Left a long bright train ..	......	Course due W.	......	W. R. Dawes, 'Monthly Notices,' Vol. xxvii. p. 46.
13	11 23 p.m.	Primrose Hill, London.	One-sixth diameter of full moon.	......	......	From δ Orionis to ϵ Eridani, and onwards towards the horizon.	Nucleus egg-shaped. Left a fine train.	......	......	[Identical with the preceding; see Appendix I.]	T. Crumplen.
13	11 29 p.m.	Birmingham ...	=Sirius	Orange colour	......	From Musca to ι Ceti.	Left a red train for 2 secs.	......	Radiant, μ Leonis	......	W. H. Wood.
13	11 30 p.m.	Primrose Hill, London.	2× ♀	......	......	From ½° below Castor to 2° above Aldebaran.	......	......	......	......	T. Crumplen.
13	11 30 p.m.	Hawkhurst (Kent).	Brighter than Sirius	......	......	Through the zenith	Left a train at least 60° long.	......	......	[Probably identical with the preceding or with the following.]	Communicated by A. S. Herschel.
13	11 30 30 p.m.	Primrose Hill, London.	One-eighth diameter of full moon.	......	......	Shot from Castor across the Pleiades, and 5° beyond.	Left a ruddy streak	......	......	Well observed......	T. Crumplen.
13	11 37 38 p.m.	Observatory, Aberdeen.	Twice as bright as Venus.	Same colour as Venus.	......	Passed 3° above the pointers (α and β) Ursæ Majoris, and parallel with them.	The nucleus suddenly burst without noise, and remained suspended like a nebulous cloud, visible for some seconds.	......	......	......	D. Gill.
13	11 45 p.m.	Haddenham, (Bucks).	As bright as Venus at maximum.	......	......	Shot from Mars over the zenith.	Left a long bright zenith..	......	......	......	W. R. Dawes, 'M^y Notices,' Vol. xxvii. p. 46.
13	11 48 p.m.	Primrose Hill, London.	One-sixth diameter of full moon.	......	......	From α Aurigæ to 3° above η Tauri, and beyond. End not seen.	......	......	......	......	T. Crumplen.
13	11 59 p.m.	Hawkhurst (Kent).	Almost as bright as Venus.	......	......	Passed near the Pole-star, and disappeared in Cassiopeia.	Two meteors exactly pursuing each other.	......	......	A binary pair	Communicated by A. S. Herschel.
14	12 5 a.m.	London	Very large meteor..	......	......	......	Train like sparks from a rocket-stick.	......	......	Another tolerably large one about 12^h 45^m a.m., and a third very bright one about 1^h 25^m a.m., but not equal in size to the first, though perhaps equal in train.	'Evening Standard,' Nov. 15.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Nov. 14	h m s 12 6 30 a.m.	Haddenham, Bucks.	As bright as Venus at maximum.	....	....	From a little south of Procyon to 15° above Sirius.	....	....	....	....	W. R. Dawes, 'Monthly Notices,' vol. xxvii. p. 46.
14	12 10 a.m.	Carlton Hill Observatory.	Large meteor	....	....	....	Left a train for 12 minutes	....	....	....	C. P. Smyth.
14	12 17 a.m.	Birmingham ...	$=♃$	White	1·5 second ...	From α Leonis α= δ= to 149°+8°	Left a brilliant green train for $3\frac{1}{2}$ seconds.	....	Directed from η Leonis	....	W. H. Wood.
14	12 28 a.m.	Ibid	$=♃$	Pale green ...	2·5 seconds ...	From 150°+38° to α Ursæ Majoris.	Left a greenish streak ...	....	....	....	Id.
14	12 29 49 a.m.	Sidmouth (Devonshire).	Much brighter than Sirius.	White	Momentary ...	Just over Sirius ...	The light of the star was momentarily extinguished by the meteor's brightness. Left no streak.	Stationary ..	....	....	H. S. Heinecken.
14	12 30 a.m.	St. Andrews (Scotland).	$=♀$	....	....	From the head of Hydra to horizon.	....	....	Directed from the radiant in the head of Leo.	....	G. Forbes.
14	12 32 50 a.m.	Observatory, Glasgow.	Three or four times as bright as Jupiter.	White	1 second	From ε Honorum Frederici to β Pegasi.	Left a thin bright train. The first part, broken into pieces, quickly disappeared. The latter half, 8° long, soon formed a wisp $\frac{1}{2}$° wide, concave to the south, which gradually collected itself into a knot 1° wide, and drifted south to α Andromedæ, which it reached at $12^h\ 37^m$, and soon afterwards disappeared. Total duration 5 minutes.	....	....	....	A. S. Herschel and A. Macgregor.
14	12 40 45 a.m.	Ibid	Two or three times as bright as Venus.	White	1 second ...	From $\frac{1}{2}$ (α, γ) Ursæ Majoris to ν Ursæ Minoris.	Left a brilliant straight streak upon its whole course. The first half became diffuse, collecting itself at the same time into a knot at $\frac{1}{2}$ (δ Ursæ Majoris, λ Draconis), brightening up as it did so, and then drifted slowly to $\frac{1}{2}$ (α, β) Ursæ Majoris, where it disappeared at $12^h\ 49^m$ a.m. Total duration 8 minutes 15 seconds. The latter half of the streak remained in a straight line, and so faded in less than 30 seconds.	....	....	....	Id.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Nov. 14	h m s 12 41 a.m.	St. Andrews (Scotland).	....	....	....	Position of the meteor not recorded. The oval mass of the train disappeared in the Milky Way, close to θ Persei.	Triple meteor, each equal to Venus. A part of the train got shorter and thicker, until it was of an oval shape. This part remained visible until 12^h 49^m a.m., the stars being visible through it.	....	....	[Identical with the preceding; see Appendix I.]	G. Forbes.
14	12 41 30 a.m.	Observatory, Aberdeen.	Twice as bright as Venus.	....	....	Commenced in Leo, and disappeared in the western horizon, crossing the zenith completely across the vault.	Left a long train which remained luminous for 30 seconds after the disappearance of the nucleus.	An arc of 160°.	Directed from Leo	....	D. Gill.
14	12 45 a.m.	Birmingham ...	Brighter than a 1st mag.*., then equal to Venus.	Blue	4 seconds......	Stationary at $\alpha=148°$, $\delta=+25°$.	Left no train	Stationary object.	....	....	W. H. Wood.
14	1 7 a.m.	Primrose Hill (London).	Large and bright...	....	....	Disappeared 5° below Aldebaran.	Left a train visible in the telescope for 10 minutes.	....	....	The train was first a band about 5′ broad, and then became a circular patch slightly elongated eastwards, which drifted about 5° towards the north-west horizon before it disappeared.	T. Crumplen and H. J. Wix.
14	1 8 a.m.	Cardiff	3 × ♃	Purple	....	Appeared near Castor, and shot across the Pleiades.	Left a train some minutes broad, and at first quite straight. A part of the train, 15° long, near the Pleiades and Aldebaran, remained visible after the ends had faded and assumed a serpentine form. After this it took the form of a small oval cloud, and moved from between α and ζ Tauri towards γ Orionis; being visible as a faint cloud until 1^h 20^m a.m.	....	....	The brightest meteor of the night.	A. and J. Thompson.
14	1 8 a.m.	Stretton (Hereford).	Very large meteor..	....	....	Passed across α Orionis, and disappeared beneath the Pleiades at a point where two lines drawn from those stars unite to form a right angle about equidistant from both.	Left a streak which remained visible for 2^m 8^s.	....	....	[Identical with the preceding.]	H. Cooper Key.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Nov. 14	h m s 1 8 9 a.m.	Sidmouth.........	One-third diameter of full moon.	....	....	From the fore foot of Ursa Major to Cassiopeia.	Left a splendid bluish train which was very conspicuous for six minutes, and remained visible for at least ten minutes.	....	....	[Identical with the preceding; see Appendix I.]	H. S. Heinecken.
14	1 8 20 a.m.	Wimbledon	....	....	....	Commenced near Capella, and disappeared near β Ursæ Minoris.	....	40°	S. to N.; obviously unconformable to the Leo radiant.	....	F. C. Penrose.
14	1 10 a.m.	Chesham (Bucks)	One-third of the moon's apparent diameter.	Very red	2 seconds ...	Moved at an altitude of 10° along the N.E. horizon.	Left a magnificent green train.	....	Moved nearly horizontally.	Illumined the whole north-east horizon. It partly disappeared, and lighted up again, in its course.	C. Grover.
14	1 15 a.m.	London	Large meteor	....	....	Commenced nearly at ϵ Orionis.	Left a bright streak, a part of which remained visible as a fleecy cloud of faintly luminous light for several minutes.	....	....	....	'Evening Standard.'
14	1 20 a.m.	Wimbledon	Very bright meteor, probably as bright as Venus.	....	....	In the S.W.........	Left a train plainly visible for two minutes.	....	Towards S.W............	The meteor itself was not seen, but it produced a very sensible light.	F. C. Penrose.
14	1 23 40 a.m.	Radcliffe Observatory, Oxford.	....	....	....	Appeared in the sword-belt of Orion.	Left a bright streak; at first attached to ζ Orionis, but afterwards separating from it to a distance of one degree.	....	....	The streak remained visible four or five minutes, collecting itself into a ball of faint cometic appearance, of about 15′ in diameter, before it disappeared. [Seen also at Haddenham, Bucks, by Mr. Dawes].	R. Main, 'Monthly Notices,' vol. xxvii. p. 45.
14	1 27 28 a.m.	Sidmouth.........	Quite one-third diameter of full moon.	....	....	A few degrees south of the zenith.	Left a train which was very conspicuous for three minutes.	....	E. to W.	....	H. S. Heinecken.
14	1 30 a.m.	Haddenham (Bucks).	About the size of Mars.	Dull colour of red-hot iron.	Motion much slower than that of most others.	From near Procyon; passed a little above α and γ Orionis, disappearing about 25° W. of γ Orionis.	Perfectly round; like a large red-hot shot at a great distance. Its brightness gradually faded after passing Orion, without any appearance of combustion, and it left no train.	....	....	The attention of another observer was called to it, who saw it exactly the same.	W. R. Dawes, 'Monthly Notices,' vol. xxvii. p. 48.
14	1 40 33 a.m.	Observatory, Glasgow.	3 × ♃	White	1·3 second ...	From ι Tauri to 3° south of α Piscium.	Disappeared with a sudden flash; nearly as bright as Venus; leaving a patch of green light at the spot for fifteen seconds.	....	....	....	A. S. Herschel and A. Macgregor.

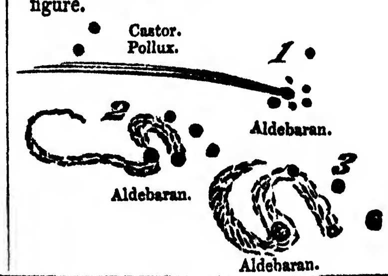
Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Nov. 14	h m s 1 45 a.m.	London	Large meteor	Greenish yellow.	....	Shot from near Regulus through the belt of Orion.	Left a train of steel-grey colour, which remained visible for nearly three minutes, although partially obscured by fleecy clouds.	....	....	....	J. Browning.
14	1 51 a.m.	Birmingham ...	= ♃	Blue or greenish.	1·5 second ...	Commenced at λ Leonis.	Left a bright train	4°	Directed from ζ Leonis.	....	W. H. Wood.
14	1 59 a.m.	Ibid	= ♃	White or green	2 seconds ...	From ζ Leonis to ε Ursæ Majoris.	Left a train	....	....	....	Id.
14	2 6 a.m.	Ibid	= ♃	Deep red	2·5 seconds ...	Appeared at δ Leonis.	Left a brilliant train	4°	Directed from γ Leonis.	....	Id.
14	2 10 a.m.	Wisbeach, Cambridgeshire.	Larger than Venus	Blue	4 seconds......	From Sirius to β Leporis.	Left a train	15°	Horizontal	....	S. H. Miller.
14	2 10 a.m.	Newcastle-upon-Tyne.	As bright as Venus..	....	....	Passed through Cassiopeia, and onwards to β Pegasi, when it became extinct.	Left a long luminous streak which gradually collected to a nebulous cluster. The line and cluster moved 5° and remained visible four minutes.	....	....	....	T. P. Barkas.
14	2 12 a.m.	Beeston Observatory, Nottingham.	....	....	....	Passed 2° above Procyon.	Left a streak that was visible three minutes, and drifted slowly along in a south-west current.	....	....	Possibly identical with the preceding, at Wisbeach, $2^h\ 10^m$ a.m.	E. J. Lowe.
14	2 12 30 a.m.	Hawkhurst (Kent).	As bright as Sirius	....	....	Disappeared at β Arietis.	Left a train (*a*), of which the part from α to β Arietis lasted fully six minutes by watch, and drifted gradually southwards (*b*), gathering together, and curving and turning as it went, so that another brilliant meteor (*c*), also conformable, crossed over it almost at right angles; see figure.	Very long path.	....	....	Communicated by A. S. Herschel.

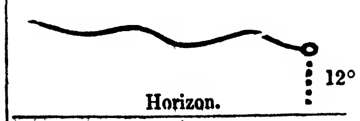


Aries.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Nov. 14	h m s 2 13 a.m.	St. Andrew's, Scotland.	= ♀	....	....	Position a little north of α Ceti.	Left a train for 2 minutes	....	....	....	G. Forbes.
14	2 14 a.m.	Observatory, Glasgow.	3 × ♃	White	1·5 second	From $\frac{1}{2}$ (α, θ) Geminorum to $\frac{1}{2}$ (α, δ) Tauri.	Left a bright streak on its whole course, divided into two portions at ι Tauri. The part from ι to α Tauri became curved, concave to the south, and collected itself into a knot, which drifted across γ Orionis southwards, half-way to λ Orionis, and disappeared at the latter point at 2^h 19^m 30^s a.m. (Duration 5 minutes 45 seconds.)	....	....	....	A. S. Herschel and A. Macgregor.
14	2 15 a.m.	Peebles	Very brilliant meteor.	Bright blue	....	Appeared between the zenith and Orion, and shot far westward.	Left an orange-yellow streak for 60 seconds.	....	....	....	'Daily Review,' Nov. 16, 1866.
14	2 15 30 a.m.	Wisbeach	Equal to Venus	....	20 seconds	From β Geminorum to λ Tauri.	Left a train which lingered several seconds.	25°	Directed from Leo	....	S. H. Miller.
14	2 15 43 a.m.	Greenwich	Twice as bright as Jupiter.	Green	$1\frac{1}{2}$ second	Burst near η Leonis	The meteor burst into several sparkling fragments and left a dense vapour which entirely obscured η Leonis.	Nearly stationary.	....	The vapour, while dense, was examined through the spectroscope, but nothing could be elicited. After the lapse of some seconds, the star (η Leonis) was seen faintly through the vapour, but this appearance was not dissipated until one minute and a half had elapsed; the vapour gradually fading away during that time.	W. C. Nash.
14	2 16 a.m.	Birmingham	Brighter than Venus.	Green	2 seconds	α= δ= From 148° + 25° to 135 + 20 .	Left a broad green train in sight for one or two minutes.	....	....	....	W. H. Wood.
14	2 20 a.m.	Hawkhurst (Kent).	= 1st mag.*, then 2 × ♀.	....	....	Commenced on a line from ε Leonis, continued through ζ Leonis, to about the distance between those stars.	Suddenly blazed out just before disappearing, leaving a puff and a short tail, which lasted two minutes and fifty seconds, and drifted very slightly eastward.	Equal to the space between ε and ζ Leonis.	Directed from the same two stars.	....	Communicated by A. S. Herschel.
14	2 39 a.m.	Beeston Observatory, Nottingham.	Eight times as bright as Venus.	Bright blue	....	Just above the N.N.W. horizon.	....	....	....	Seen through trees	E. J. Lowe.
14	2 40 a.m.	Oundle (Notts.)	Exceedingly large fireball.	....	....	Fell in the north point of the horizon.	....	....	....	For a moment it lit up the whole heavens as with the light of day.	H. Weightman.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Nov.14	h m s 2 40 a.m.	Carlton Hill Observatory.	Large meteor	....	....	The luminous streak remained nearly stationary between the 'Pointers' in Ursa Major and Polaris.	Left a train for ten minutes, which underwent a series of changes of its form before it disappeared.	....	....	Cast the observer's shadow on the ground.	C. P. Smyth.
14	2 40 a.m.	Newcastle-upon-Tyne.	Three times as bright as Venus.	....	....	Passed from Leo north of α and β Ursæ Majoris, skirting Polaris, and became invisible near Alderamin, α Cephei.	Left a train like molten silver several minutes in width and 15° in length, which gradually became contorted, like a skein of silk when thrown upon a table, until it resembled a letter L, or a horseshoe; the summit of the arch pointing to Ursa Major, and curved round β Cephei.	....	....	....	T. P. Barkas.
14	2 41 a.m.	Glasgow Observatory.	Very large	....	....	....	Left a bright orange-red light cloud of horseshoe form (fig. 1), extending from 5 Canum Venaticorum to near γ, δ Ursæ Majoris. At 2^h 44^m a.m., the streak was heart-shaped (fig. 2), the apex at χ Ursæ Majoris. At 2^h 48^m a.m., one branch extended to $\frac{1}{2}(\beta, \gamma)$, and the apex was at ($p$) Ursæ Majoris (fig. 3). At 2^h 52^m a.m., the extremity of one branch was at the 'Pointers' (α, β); the apex was at ξ Ursæ Majoris, and the other extremity was stationary throughout the time at 5 Canum Venaticorum, until 2^h 58^m a.m., when the light faded away and disappeared.	....	....	....	A. S. Herschel and A. Macgregor.
14	2 40 58 a.m.	Observatory, Aberdeen.	One-fifth diameter of full moon.	....	Slow motion, and apparently diminishing speed.	Commenced between Mars and Pollux, rather nearer to the latter. Disappeared at θ Tauri. Fig. 1, appearance of the streak when first deposited. Fig. 2, ditto at 2^h 43^m a.m. Fig. 3, ditto at 2^h 44^m 30^s a.m.	Left a luminous streak which assumed successive forms, as in the figure.	....	....	The light of the meteor was more like sunlight than any other. The brightest meteor of any seen on this night. No report heard. (See Appendix II.)	D. Gill.



Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Nov. 14	h m 3 41 30 a.m.	Royal Observatory, Greenwich.	2 × ♃	Bright bluish white.	2 seconds	From the direction of θ Draconis towards τ Cygni.	Left a train lasting 10 seconds after disappearance of the meteor.	10°	Inclined	This meteor burst	Arthur Harding.
14	3 6 a.m.	Wimbledon	Bright meteor	......	......	Centre at α= 13h 12m, δ= +37°.	Left a bright short train which remained visible in the telescope for many minutes.	......	......	The train seen in the telescope appeared like a riband with many bends.	F. C. Penrose.
14	3 7 a.m.	Wisbeach	......	......	7 seconds	First appeared at ½ (γ, ζ) Leonis.	Left a train which curled up thus— 	......	......	The curved train remained visible for three minutes, and appeared like a dim nebula in the telescope. (See Appendix.)	S. H. Miller.
14	3 18 20 a.m.	Beeston Observatory, Nottingham.	Large meteor	......	......	Crossed ε Ursæ Majoris.	......	......	......	......	E. J. Lowe.
14	3 20 a.m.	Wimbledon	About equal to Mars	Very red	Slow motion	Disappeared in the S. by W., at an altitude of about 12° above the horizon.	Its path appeared undulating as in the sketch. 	......	Nearly horizontal, from left to right. Slightly unconformable in its direction.	......	F. C. Penrose.
14	3 26 a.m.	Wisbeach	Equal to Venus	Blue	5 seconds	From near β Ursæ Majoris to ½ (γ, ν) Ursæ Minoris.	Left a train for 20 seconds	......	......	......	S. H. Miller.
14	3 35 a.m.	Wimbledon	......	Red	Slow motion; 3 seconds.	From ι Ursæ Majoris to Comæ Berenices.	......	......	From W. to E. Totally unconformable in path to the Leo Radiant.	Unsteady flight	F. C. Penrose.
14	3 39 a.m.	Beeston Observatory, Nottingham.	Large and bright meteor.	......	......	Crossed ε Ursæ Majoris.	......	......	......	......	E. J. Lowe.
14	5 35 a.m.	Wimbledon	Very bright meteor, brighter than Sirius.	......	......	Disappeared near 5 Monocerotis.	Left a very brilliant and rather persistent streak.	......	......	Two other bright meteors appeared nearly at the same time.	F. C. Penrose.
14	6 16 a.m.	Near Primrose Hill (London).	Bright meteor	......	Rapid	In the S.W.; descending to the horizon.	......	......	......	Seen in broad daylight and in sunshine.	T. Crumplen.
14	6 40 p.m.	York	= 1st mag.*	Bluish	⅓ second	From ½ (γ, χ), past χ Ursæ Majoris.	Left a train which lasted 1½ minute.	12°	......	......	R. G. and C. Barclay, and A. J. Crossfield.
14	6 40 p.m.	Greenock	Brighter than any in the previous shower.	......	......	It came from the east and shot upwards.	......	......	......	The light was so great as to cause observers looking in an opposite direction to turn round. Seen also at Glasgow.	'North British Daily Mail,' Nov. 16th.
14	6 55 p.m.	York	= 1st mag.*	Orange	⅔ second	From α Persei to within 2° of α Aurigæ.	Left a slight train; moved in curves, seeming to oscillate.	19°	Inclined 	......	J. E. Clark.

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1866. Nov. 14	h m s 8 8 p.m.	York	=3rd mag.*	Yellow	½ second	From γ Andromedæ to α Arietis.	Left a very slight train	15°			A. C. Marriage.
14	8 11 p.m.	Ibid	=3rd mag.*	Bright yellow	½ second	From α to λ Aurigæ.		7°			Id.
14	8 11 30 p.m.	Ibid	=2nd mag.*	Yellow	½ second	From δ Andromedæ to α Cassiopeiæ.		15°			S. Thomson.
14	8 16 p.m.	Ibid	=3rd mag.*	Yellow	½ second	From 16 Cephei to ψ Draconis.		13°			A. C. Marriage.
14	8 21 p.m.	Ibid	=1st mag.*	Yellow	1½ second	From γ Cephei to 78 Andromedæ.	Left a short train for a quarter of a second.	32°			A. K. Brown.
14	8 26 p.m.	Ibid	=2½ mag.*	Reddish	½ second	From γ Andromedæ to α Arietis.		13°			A. C. Marriage.
14	8 28 p.m.	Ibid	=2nd mag.*	Orange	½ second	From ι to γ Ursæ Minoris.		12°	Inclined at an angle of 80°.		Id.
20	4 0 a.m. (local time.)	Nashville, Tennessee (U. S. A.).	Appeared as large as the sun.		Rapid motion	In the direction of Rome (Georgia).	Like a ball of fire lighting the whole heavens.		Moving south-west	Exploded apparently about ten miles off with a tremendous report like a 40-lb. cannon, which shook the earth and made the windows rattle.	New York 'Journal of Commerce' and 'World,' Nov. 24th.
25	5 52 p.m.	West Hendon (Sunderland).	=2nd mag.*			Near α Lyræ					T. W. Backhouse.
25	7 30 p.m.	Birmingham	=3rd mag.*	Orange	1 second	α= δ= From 42° +10° to α Ceti.					W. H. Wood.
25	7 41 p.m.	Ibid	=3rd mag.*	Blue	1·5 second	From 5° + 4° to 11 − 25					Id.
27	6 2 30 p.m.	York	=♃	Greenish	1 second	From λ Boötis to η Herculis.	Left a train of sparks for an instant.	37°	Moved in a curve from Ursa Major.	It seemed brighter at one time and hazy at another, but each stage was about the same brightness. There was still a good deal of twilight.	J. E. Clark.
27	7 37 p.m.	Ibid	=3rd mag.*	Yellow	½ second	From β Cassiopeiæ to within 4° of β Lacertæ; very near the zenith.		30°	Directed from γ Leonis.		Id.
27	7 57 p.m.	Ibid	=1½ mag.*	Yellow	1 second	From α Cassiopeiæ to ε Cygni.		40°	Directed from γ Leonis.	Another 3rd magnitude meteor near α Cassiopeiæ nearly simultaneous.	J. E. Clark and J. Waller.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Nov. 27	h m s 8 35 p.m.	York	=♃	Yellow	2 seconds	From η to a little west of β Cygni.	Left a slight streak for a moment.	24°	Downwards; 75°; inclined; from γ Leonis.	It nearly disappeared in the middle of its course, but regained its former brightness.	R. G. Barclay.
28	6 0 a.m.	Ibid	=2nd mag.*	Yellow	½ second	From within a few degrees of α Leonis towards the south.	...	...	...	...	C. Barclay.
28	8 55 p.m.	Ibid	=2nd mag.*	Yellow	½ second	From Cygnus towards Aquila.	...	6° while in sight.	From γ Leonis	Seen through a break in clouds.	J. E. Clark.
28	9 0 p.m.	Ibid	=1st mag.*	Yellow	½ second	Same as the last	...	10° while in sight.	Similar to the last	As described in the last meteor.	Id.
30	6 49 p.m.	West Hendon (Sunderland).	=2nd mag.*	...	...	Disappeared at ½ (Castor, θ Aurigæ).	...	...	Directed from Polaris	...	T. W. Backhouse.
30	7 51 30 p.m.	York	=2nd mag.*	Yellow	1 sec., quick	From 3° W. of Alpharet to 3° E. of Algenib.	...	12°	Inclined 80°	At 7^h 30^m, a small meteor on nearly the same path.	J. E. Clark and F. Bewley.
30	8 14 15 p.m.	Ibid	=2½ mag.*	Yellow	1 second	From Mirfak to within 5° of the Pleiades.	...	24°	...	...	A. C. Marriage.
30	8 17 30 p.m.	Ibid	=2nd mag.*	Yellow	1 sec., rapid	From 10° E. of Mirfak to δ Andromedæ.	...	35°	...	...	J. E. Clark and A. C. Marriage.
30	8 35 p.m.	Ibid	=♃	Light blue	½ sec., slow	From 10° N. of α Cygni to δ Delphini.	Disappeared gradually; left a slight train for 1 second.	45°	...	...	J. E. Clark.
30	8 38 p.m.	Ibid	=3rd mag.*	Yellow	½ second	From ζ Aurigæ to within 5° of the Pleiades.	...	19°	...	...	A. C. Marriage.
30	9 12 p.m.	Ibid	=3rd mag.*	Yellowish	About ½ sec.	Seen near Ursa Major.	...	...	...	...	F. H. Longman.
30	10 2 p.m.	Ibid	Half as bright again as Jupiter.	...	One-tenth of a second while in sight.	Appeared in the W.N.W., a few degrees above the horizon. Disappeared behind a house-roof.	...	3° while in sight.	...	Seen from a third story almost on a level with the opposite roof.	J. E. Clark.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Dec. 2	h m s 7 30 to 7 45 p.m.	York	....	....	....	....	....	....	....	Sky clear; a strict watch kept; none seen.	J. E. Clark.
3	9 27 p.m.	Ibid	=1st mag.*	Yellow	½ second, very rapid.	From 10° E. of, to 2° W. of Algenib.	Left a very slight train ...	12°	Nearly horizontal	Appeared from behind a cloud whose edge it slightly illuminated.	J. E. Clark and A. C. Marriage.
4	8 23 p.m.	Ibid	=1st mag.*	Very bright yellow.	½ second, very rapid.	From 4° S. of β to within 1° of θ Aurigæ.	Towards the end of its course it left a bright green train 2° long, and 15′ broad for about 1 sec.	8°	Directed at first from β Aurigæ.	Path distinctly curved, as shown by the arrow.	J. E. Clark.
4	9 44 p.m.	Ibid	=3rd mag.*	Blue	½ sec., rapid...	From α Equulei to within 3° of ν Capricorni.	....	17°	....	....	Id.
5	9 17 p.m.	West Hendon (Sunderland).	=2nd mag.*	White	Slow	Disappeared at R. A. 11h 40m, N. Decl. 61½°.	....	....	Perpendicular	....	T. H. Backhouse.
5	9 58 30 p.m.	York........	=1st mag.*	Light yellow...	⅛ sec., rapid...	From α Aurigæ towards the N.	....	5°........	Horizontal	....	J. E. Clark.
5	10 10 p.m.	West Hendon (Sunderland).	=3rd mag.*	Orange colour	Quick	Disappeared at R. A. 13h 36m, N. Decl. 62°.	....	Short	Directed from ½ (β, γ) Ursæ Minoris.	Four other meteors seen during the evening.	T. W. Backhouse.
7	9 21 30 p.m.	York	=1½ mag.*	Yellow	1 second	From 4° E. of α Aurigæ to h Ursæ Majoris.	Extremely bright meteor; left a slight train.	25°	....	From 7h 40m to 7h 55m; on the morning of the 7th watched for meteors, but none seen.	A. C. Marriage and J. E. Clark.
7	10 4 p.m.	West Hendon (Sunderland).	=2nd mag.*	....	....	Disappeared at ½ (ξ Geminorum, to β Canis Minoris).	Left a short sparkling train.	....	Directed from ξ Geminorum.	....	T. W. Backhouse.
8	5 6 p.m.	York	=Mars or ♃	Red	1½ second ...	From 10° to 40° below Polaris.	A few sparks were seen to fall from it when brightest.	....	.... Ursa Major.	Only a few stars visible in twilight.	J. E. Clark.
8	7 49 p.m.	Ibid	=2nd mag.*	Yellow	1 second, slow	α= δ= From 38°+ 55° to 73 + 58	....	10°	Directed from Cassiopeia	....	Id.
8	8 0 10 p.m.	Ibid	=3rd mag.*	Blue	¼ sec., rapid...	From 87°+ 45° to 105 + 43	....	10°	From Cassiopeia	....	Id.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Dec. 8	h m s 8 4 p.m.	York	=2nd mag.*	Blue	$\frac{1}{2}$ sec., rapid...	α= δ= From 18° +26$\frac{1}{2}$° to 12$\frac{1}{2}$ +38$\frac{1}{2}$	....	10°	....	....	J. E. Clark.
8	8 24 p.m.	Ibid	=2nd mag.*	Yellow	$\frac{1}{2}$ sec., rapid...	From 25°+63° to 336 +58	....	17°	From Cassiopeia	....	Id.
8	8 27 p.m.	Ibid	=1st mag.*	Green	$\frac{1}{2}$ second	From 70°+66$\frac{1}{2}$° to 20 +98$\frac{1}{2}$	....	12°	....	[The north declination at disappearance is apparently in error.]	Id.
8	8 28 30 p.m.	Ibid	=2nd mag.*	Red	$\frac{1}{2}$ sec., rapid...	From 90°+60° to 105 +40	....	10°	Perpendicular from Cassiopeia.	....	Id.
8	8 47 30 p.m.	Ibid	= $\frac{1}{2}$ apparent diameter of full moon.	Red	1 second	From 323°+70° to 245 +62$\frac{1}{2}$	Was not very bright, but emitted sparks which disappeared with the nucleus; the latter separated into small fragments at disappearance.	18°	From Cassiopeia	....	S. Thomson.
8	9 4 p.m.	Ibid	=1st mag.*	Yellow	$\frac{1}{2}$ sec., rapid...	From 348°+27$\frac{1}{2}$° to 350 +12	Left a slight train	13°	From β Cassiopeia	....	J. E. Clark and A. C. Marriage.
8	9 12 p.m.	Ibid	=3rd mag.*	Blue	$\frac{1}{2}$ sec., rapid...	From 11° +16° to 10$\frac{1}{2}$ +11	....	5°	....	....	J. E. Clark.
8	9 15 p.m.	Ibid	= ♃	Yellow	1 second while in sight.	From 310°+45° to 318 +30	Left a bright green train during its whole course.	20° while in sight.	From Cassiopeia	Came into view from behind a house and gradually disappeared.	J. E. Clark and A. C. Marriage.
8	9 28 p.m.	Birmingham ...	=2nd mag.*, then =Sirius.	Ruby-red, then orange-colour.	....	From δ Draconis to R. A. 290°, N. Decl. 35°.	Left a train 25° in length	... .	Directed from η Leonis	Increased from a 2nd mag.* to larger than Sirius; drew a smoke-like tail which disappeared with the meteor.	W. H. Wood.
8	9 35 p.m.	York	=2nd mag.*	Yellow	One-fifth sec., very rapid.	α= δ= From 3°+32$\frac{1}{2}$° to 11 +16$\frac{1}{2}$	Extremely rapid, and rather faint.	15°	From Cassiopeia	....	J. E. Clark and C. Barclay.

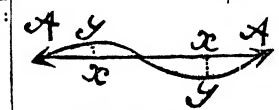
Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Dec. 8	h m s 9 37 p.m.	York	=1st mag.*	Yellow	One-tenth sec. while in sight.	$\alpha=$ $\delta=$ From 23°+50° to 25 +47	Left a slight train	3°	From Cassiopeia		J. E. Clark.
8	10 43 p.m.	Birmingham	=1st mag.*	Ruby-red	1·5 second	From 95°− 1° to γ Canis Majoris.	Left a train				W. H. Wood.
10	5 28 p.m.	York	=3rd mag.*	Bright yellow	1 second	$\alpha=$ $\delta=$ From 313°+47° to 48 +48¼		45°		Crossed the zenith	J. E. Clark.
10	5 28 3 p.m.	Ibid	=3rd mag. stars	Dull red	1 second	From 313°+47° to 48 +48½	This meteor appeared to consist of 5 meteors very close together; so that a circle of 20′ of diameter would have enclosed all of them. It moved in just the same path as the last.	45°		Crossed the zenith	Id.
10	5 42 30 p.m.	Ibid	=1st mag.*	Yellow	½ second	From 166°+63½° to 210½+65	Left a slight train	12°	Directed from Castor		Id.
10	6 49 p.m.	Ibid	= one-eighth diameter of full moon.	Pale yellow	½ second	From 7°+33° to 5 +20		8°			A. C. Marriage.
10	7 1 p.m.	Ibid	= ♃	Bright yellow	1½ sec., very slow.	From 115°+33° to 142 +73	Left a green train for 1 second.	40°	Directed from Castor	Moved in a curve	J. E. Clark and A. C. Marriage.
10	7 10 p.m.	Ibid	=1st mag.*	Yellow	¾ second	From 54°+20° to 38 +12	Left a slight train which disappeared with the meteor.	12°	From the Pleiades		J. E. Clark.
10	8 41 p.m.	Ibid	=1st mag.*	Yellowish	½ second	From 72°+46° to 54 +50		8°	From Castor	Clouded view	Id.
10	9 20 p.m.	Ibid	=3rd mag.*	Yellow	One - tenth second; almost instantaneous.	From 26°+62½° to 32 +61		3°	From Cassiopeia		A. C. Marriage.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Dec. 10	h m s 9 20 15 p.m.	York	=3rd mag.*	Yellow	Same as the last.	$\alpha=$ $\delta=$ From 26°+62½° to 32 +61	....	3°	From Cassiopeia	....	A. C. Marriage.
10	9 21 p.m.	Ibid	=3rd mag.*	Yellow	One-eighth second; moderate speed.	From 32°+61° to 45 +53	....	5°	....	....	Id.
10	11 25 p.m.	Ibid	=♀	Bluish white	1 second, very slow.	From 112°+32° to 114 +35	....	2°	....	Fifteen meteors seen between 11 and 12 o'clock, mostly radiating from Castor.	T. H. Waller.
10	11 37 p.m.	Ibid	=1st mag.*	White	1 second, slow	From 141°+24° to 150 +42½	....	11°	....	....	Id.
11	12 48 a.m.	Ibid	=3rd mag.*	Yellow	¼ second	From 131°− 3° to 121 −19	....	15°	....	....	D. Marriage.
11	5 48 p.m.	Ibid	=♀	Yellow	1½ sec., very slow.	From 340°+33° to 325 +30	Drew a red tail at the end of its course, which disappeared with it.	13°	....	....	J. E. Clark.
11	6 27 p.m.	Ibid	=1st mag.*	Yellow	One-eighth sec., rapid.	From 45° +65° to 46½ +47	....	13°	....	....	Id.
11	7 2 p.m.	Ibid	=♃	Yellowish	1 second, slow	From 45°+20° to 38 + 5	....	15°	....	Very misty sky with cirri, which it illuminated to the breadth of 2° or 3°.	J. E. Clark and A. J. Crossfield.
11	7 14 p.m.	Ibid	=2nd mag.*	Yellow	½ sec., rapid	From 105°+60° to 322 +70½.	Left a slight train	30°	....	....	A. J. Crossfield.
11	7 29 p.m.	Ibid	=1st mag.*	....	¾ second	From 332° +33° to 333½ +11	Left a slight train	....	....	....	J. E. Clark.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Dec. 12	h m s Morning ...	Kishnaghur, India.	Bright meteor......	....	....	Shot across Gemini from α Hydræ to θ Ursæ Majoris.	Left a long train..........	....	S. to N.; quite across the principal radiant region for the night.	See Appendix IV., 3 ...	W. Masters.
12	5 41 p.m.	York	=1st mag.*.........	Yellow	½ second, very rapid.	α= δ= From 17°+47° to 30 +26	....	12°	↙	....	J. E. Clark.
12	7 29 30 p.m.	Ibid	=2nd mag.*	White	½ sec., quick motion.	From 30°+22° to 8 +30	....	15°	↗	....	A. K. Brown.
12	7 33 p.m.	Ibid	=1st mag.*.........	White	½ sec., slow ...	From 98 +48° to 87 +50	Left a red train	3°...........	↗	....	J. E. Clark.
12	7 38 p.m.	Ibid	=3rd mag.*	Light yellow...	½ sec., rapid...	From 240°+67° to 250 +45	....	18°	↙	....	A. J. Crossfield.
12	7 42 p.m.	Ibid	=3rd mag.*	Yellow	½ sec., rapid...	From 210°+65° to 240 +27	....	40°	↙	Two minutes later two meteors, 3rd magnitude, from Cassiopeia towards Capella. (A. C. M.)	J. E. Clark and A. J. Crossfield.
12	7 47 p.m.	Ibid	=1st mag.*.........	White	½ second	From 98°+25° to 112 +32	....	7°...........	....	Five others in five minutes about the same time.	Id.
12	7 48 p.m.	Ibid	2×Capella	White	½ second	From 79°+28° to 65 +18½	....	11°	....	Two other meteors nearly at the same time.	T. H. Waller and A. C. Marriage.
12	8 4 p.m.	Ibid	=3rd mag.*	Yellow	1 second, slow	From 132°+40½° to 163 +47½	....	12°	↖	Two other meteors at about the same time.	Id.
12	8 5 p.m.	Ibid	=Mars	Blue	1½ second ...	From 20°+88° to 318 +62	Left a bright green train for a short time.	15°	Inclined	....	Id.
12	8 10 p.m.	Ibid	=1st mag.*.........	Yellow.........	1 second	From 309°+44° to 300 +15	Left a slight train	30°	Directed from Castor ... ↙	Grew gradually fainter..	J. E. Clark.
12	8 10 p.m.	Ibid	=3rd mag.*	Reddish	½ second	From 76°+28° to 67 +16	....	10°	↘	This and the last were seen at the same moment.	A. J. Crossfield.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Dec. 12	h m 8 13 p.m.	York	=3rd mag.*	Orange colour	½ second	α= δ= From 99°+28° to 75 +25	t a slight train in the middle of its course.	10°			W. Malone and A. K. Brown.
12	8 23 p.m.	Ibid	=♀	First yellow, then green.	1½ sec., slow	From 215°+45° to 236 +20	n the first half of its course equal 4th magnitude star, then suddenly brightened up and disappeared suddenly.			Path slightly curved	J. E. Clark.
12	9 1 p.m.	Ibid	=1st mag.*	Yellow	One-tenth sec. while in sight.	About 5° above the horizon in the N.N.E.		1½° while in sight.	Almost perpendicular		R. G. Barclay.
12	9 6 p.m.	Ibid	=3rd mag.*	White	1 second	α= δ= From 282½°+37½° to 270 +25		10°	Perpendicular		Id.
12	9 9 p.m.	Ibid	=♀	Dull yellow		From 72°+60° to 135 +68	Drew a yellowish tail, which disappeared with it.	14°			R. G. Barclay and A. C. Marriage.
12	9 12 p.m.	Ibid	=2nd mag.*	Red	½ sec., rapid	From 118°+29° to 140 +60		10°			R. G. Barclay.
12	9 14 p.m.	Ibid	=♀	Blue	1 second	From 240°+39° to 268 +52	Left a slight train	9°			Id.
12	9 24 p.m.	Ibid	= one-sixth apparent diameter of the moon.	Dull red	1½ sec., very slow.	From 220°+28° to 230 +20		17°		Although large in apparent size, it gave very little light.	J. E. Clark.
12	9 27 p.m.	Ibid	Apparent diameter 4′.	Dull yellow	½ second	From 249°+23° to 254 +21½	Looking nebulous	4°			R. G. Barclay.
12	9 58 p.m.	Ibid	=1st mag.*	Red	½ sec., rapid	From 70°+ 5° to 83 +15		15°		Seen through pretty dense clouds.	J. E. Clark.
12	10 53 p.m.	Birmingham	=4th mag.*	Blue	0·5 second	From α Tauri to α= δ= 64° +6°				Sky clouded; at 10.30, clearing; at 10.50, half cloudy.	W. H. Wood.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Dec. 12	h m s 10 54 p.m.	Birmingham ...	=1st mag.*	Blue	0·5 second ...	Commenced at α= 105° δ= −3°	Left no train	10°	Directed from α Geminorum.	Meteors very frequent. One per minute. Unassisted observer.	W. H. Wood.
12	10 56 p.m.	Ibid	Brighter than 1st mag.*.	White	0·5 second ...	Commenced at α= 314° δ= +48°	Left no train	10°	Directed from Castor ...	View clouded: sky four-fifths cloudy; overcast at 11^h p.m.	Id.
12	11 42 p.m.	Ibid	= Sirius	White	0·5 second ...	From α= 97° δ= +70° to Polaris.	....	....	Directed from δ Geminorum.	Sky four-fifths cloudy; clear in zenith only; overcast at 11^h 55^m.	Id.
13	12 5 3 a.m.	Ibid	Brighter than 1st mag.*.	White	0·25 second...	Commenced at α= 122° δ= +61°	Left no train	5°	Directed from Pollux ...	Sky one-fourth cloudy, with fine rain.	Id.
13	12 24 a.m.	Ibid	Brighter than 1st mag.*.	Orange	1·5 second ...	Commenced at γ Orionis.	....	15°	Directed from Pollux ...	Sky three-fourths cloudy	Id.
13	5 19 p.m.	York	=3rd mag.*	White	⅓ sec., rapid...	α= δ= From 13° +58° to 40 +45	....	12°	↓	....	J. E. Clark.
13	5 44 30 p.m.	Ibid	=3rd mag.*	White	½ second	From 210° +75° to 200 +70	....	4°	↙	....	A. K. Brown.
13	7 2 p.m.	Ibid	=1st mag.*.........	White	1 second	From 288° +67° to 287 +38	....	25°	↙	....	J. E. Clark.
13	7 8 p.m.	Near York	=1st mag.*.........	White	½ sec., rapid...	From a point to the eastward of the moon to a point near the moon.	....	10°	↘	....	C. Brightwen.
13	7 43 30 p.m.	Ibid	=2nd mag.*	Yellow	½ second	α= δ= From 290° +73° to 300 +52	....	10°	←	....	A. K. Brown.
13	7 59 p.m.	Ibid	=3rd mag.*	White	½ second	From 73° +41° to 84° +37	....	7°	↙	....	Id.
13	8 9 p.m.	Ibid	=2nd mag.*	White	1 second	From 165° +63° to 240 +59	Left a slight train	20°	....	....	J. E. Clark and A. K. Brown.
13	8 13 30 p.m.	Ibid	=2nd mag.*	White	½ second	From 60° +40° to 50 +47	....	8°	↗	....	F. Bewley.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Dec. 13	h m 8 18 p.m.	York	=3rd mag.*	White	½ second	$\alpha=$ $\delta=$ From 87°+40° to 74 +42	......	6°	......	......	F. Bewley.
13	8 23 p.m.	Ibid	=2nd mag.*	Yellow	⅓ sec., rapid	From 135°+48° to 135 +45	......	2°	......	......	A. K. Brown.
13	8 35 p.m.	Ibid	=2½ mag.*	White	½ second	From 207°+65° to 57 +55	Left a slight train	8°	←	......	J. E. Clark.
13	9 30 to 9 50 p.m.	Birmingham	......	......	......	......	......	......	......	Clear fine night. No meteors seen in twenty minutes. Fine display of Aurora Borealis with streamers, in the N.N.W.	W. H. Wood.
13	11 45 p.m.	Ibid	=2nd mag.*	Nucleus dark	1·5 second	From 119°+27° to α Canis Minoris.	Nucleus apparently non-luminous, but seen in relief.	......	Described two equal curves or undulations: see drawing. ↘	......  $Ax=5°\ 45'$ $xy=1\ \ 30$	Id.
14	11 55 p.m.	Alderley Edge, Cheshire.	Very large	Rainbow colours.	......	Commenced within 4° or 5° of Polaris.	At first a speck of light. Gradually grew larger, drawing a fan-shaped tail of sparks. Burst at maximum brightness.	......	Shot at an angle of 45° across the sky.	Followed by a loud detonation. Illuminated the district for miles round. Seen also at Rusholme.	S. Lavey and W. W. Chambers. 'Manchester Courier.'
15	6 30 p.m.	Brest, France	Large fireball	......	About 2 secs.	Disappeared in the constellation Lyra.	Burst with a flash at disappearance.	......	From S.E. to N.W.	......	M. Kumarec, Les Mondes, 2nd Ser., vol. xiii p. 23.
16	5 23 p.m.	York	=1st mag.*	Yellow	¼ sec., rapid	$\alpha=$ $\delta=$ From 296°+ 8° to 299 + 4	......	4°	...... ↙	Two similar meteors near the same place and nearly simultaneous.	A. K. Brown and J. E. Clark.
16	5 26 p.m.	Ibid	=1st mag.*	Yellow	1 second	From 300°+80° to 330 +60	......	20°	...... ↘	A similar one near to it ten seconds before.	Id.
19	6 27 p.m.	Ibid	=2nd mag.*	Yellow	½ second	From 152°+13° to 140 ± 0	Left a train for 2 seconds.	10°	...... ↙	......	Id.
19	6 30 p.m.	Ibid	=2nd mag.*	Yellow	¼ second	From 185°−15° to 175 −11	......	5°	...... →	......	Id.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Dec. 19	h m 6 30 p.m.	Street (Somerset).	$=$ ♀	Yellow	2 seconds ...	$\alpha=\ \delta=$ From 5 +60° to 0 −10	Left no train	70°	.... 	....	W. S. Clark.
19	6 48 p.m	York	=1st mag.∗........	Yellow	¼ second	From 151°+14° to 149 +10	Left a bright greenish train for 5 seconds, fading from the ends towards the centre.	....	.... 	....	J. E. Clark and R. G. Barclay.
22	6 30 a.m.	Falmouth	=2nd mag.∗	Reddish yellow.	3 seconds ...	From 200°−10° to 220 −16	....	15°	....	....	C. Barclay.
23	7 14 p.m.	West Hendon, Sunderland.	As bright as Venus at its brightest.	Pale yellow ...	1 second	Passed ½° above α Arietis; disappearing about midway between α Arietis and γ Pegasi.	Disappeared suddenly. Left a long faint train, broadest in the middle, and disconnected from the head, which remained visible about 1 second after the head had vanished.	At least 40°	....	....	T. W. Backhouse.
24	7 27 p.m.	Ibid	=2nd mag.∗	Orange	....	Disappeared at ⅓ (δ, ξ) Draconis.	....	....	Directed from ⅔ (ζ Draconis, γ Ursæ Minoris).	....	Id.
28	5 48 p.m.	Street (Somerset).	=1st mag.∗........	White	½ sec., slow ...	$\alpha=\ \delta=$ From 290°+50° to 278 +70	Left a short train 1° in length.	10°	....	....	J. E. Clark.
29	7 57 p.m.	West Hendon, Sunderland.	=3rd mag.∗	Bluish	....	Appeared near χ Cygni.	....	8° or 10°...	Inclined 70° to vertical, downwards to left. 	....	T. W. Backhouse.
29	8 15 p.m.	Street (Somerset).	=1st mag.∗........	Green	1 second	$\alpha=\ \delta=$ From 30°+44° to 51 +63	....	10°	....	....	J. E. Clark.
29	9 30 p.m.	Birmingham ...	=2nd mag.∗	Pale blue	1·5 second ...	From 51° + 7° to 44 − 5	....	....	Directed from α Tauri...	....	W. H. Wood.
31	8 30 p.m.	Ibid	=2nd mag ∗	White	1 second	From 20°+63° to 352 +60	....	12°	.... 	....	S. S. Clark.
31	8 31 p.m.	Ibid	=3rd mag.∗	White	5 seconds......	From 110°+33° to 101 +36	....	10°	.... 	....	E. O. Clark.
31	9 15 p.m.	Cheshire	=3rd mag.∗	Reddish	0·5 second ...	From θ Canis Majoris, halfway to Procyon.	Left no train	5°...........	From Radiant $M_{1,2}$; or K_3.	....	R. P. Greg.
31	9 20 p.m.	Ibid	=3rd mag.∗	Reddish	....	From κ Orionis to γ Geminorum.	....	8°...........	From Radiant $M_{1,2}$; or K_3.	....	Id.
1867. Jan. 2	From 11 to 11 45 p.m.	Ibid	=3rd mag.∗	Reddish	....	From β to α Arietis	....	4°...........	From Radiant $M_{1,2}$ ...	....	Id.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1867. Jan. 2	h m From 11 to 11 45 p.m.	Cheshire	=2nd mag.*		0·8 second	From Procyon to λ Cancri.			From Radiant K_3		R. P. Greg.
2		Ibid	=3rd mag.*		1 second	From 25 Monocerotis to δ Cancri.		10°	From Radiant K_3		Id.
2		Ibid	=2nd mag.*		0·5 second	From α Andromedæ to κ Honorum.			From Radiant K_3		Id.
2		Ibid	=3rd mag.*		0·75 second	From λ Ursæ Majoris to ε Ursæ Majoris, and rather further.			From Radiant K_3		Id.
2		Ibid	=3rd mag.*			From ½ (3, 5) Canum Venaticorum to ½ (ζ, γ) Ursæ Majoris.			From Radiant K_3	The display on this night very inferior to that of the 2nd of January 1863, from 11^h p.m. to 1^h 30^m a.m.	Id.
3	About 5 45 p.m.	Street (Somerset).	=1st mag.*	Red	1 second	Near the southern horizon.		10°			J. E. Clark.
3	About 5 50 p.m.	Ibid	=1st mag.*	White	1 second	From Capella to β Tauri.	Left a fine train	15°			Id.
3	About 8 0 p.m.	Ibid	=2nd mag.*	White	½ second	In the S.E.		10°	1 2	Two almost simultaneous.	Id.
3	8 2 p.m.	Ibid	=2nd mag.*	White	¼ second	Near the zenith		4°		From 8.30 to 8.45 p.m., eight meteors seen at Bridport.	J. E. Clark and T. Stevens.
16	7 25 a.m.	Falmouth	=2nd mag.*	Yellow	1 second, very rapid.	α= δ= From 150°+65° to 108 +26		40°			E. Barclay.
24	8 46 p.m.	West Hendon, Sunderland.	=2nd mag.*	Orange colour		Disappeared at ⅔ (ο, α) Piscium.		12°	From the Pleiades		T. W. Backhouse.
24	8 52 p.m.	Ibid	=2nd mag.*	Deep orange colour.		Disappeared at R.A. 12^h 40^m, N. Decl. 37°.					Id.
30	7 45 p.m	York	=1st mag.*	White	1½ second	α= δ= From 20°+60° to 40 +40	Left no train	25°			A. K. Brown.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1867. Feb. 3	h m s 7 34 p.m.	West Hendon (Sunderland).	=1st mag.*, then gradually less until it disappeared.	....	....	At first seen near β Tauri. After the head disappeared, the tail still moved on; and it went close past α Arietis, and a few degrees further.	Left a long blue train, broadest at the head; after the head went out the tail still advanced but gradually grew fainter and disappeared. It did not remain after its foremost extremity ceased to move.	At least 50°, including the path of the tail after the head disappeared.	....	A singular appearance was presented by the headless meteor shooting along, such as I never saw before. The meteor went perhaps 20° after the head disappeared.	T. W. Backhouse.
6	8 14 30 p.m.	York............	=1st mag.*	Yellow	0·5 second ...	α= δ= From 212°+58½° to 220 +53	....	....	....	Seen through clouds; a misty evening.	J. E. Clark.
6	8 18 p.m.	Ibid	=1st mag.*.........	Dull red	1 second, very slow.	From 17°+51° to 38 +57	....	10°	....	Seen through clouds ...	Id.
6	9 29 30 p.m.	Ibid	= Sirius	Bright red ...	2·5 seconds ...	From 69° +13½° to 71½ +12½	Left red sparks in the last 1½° of its course, which soon disappeared.	3°...........	Moved in a curve thus—	Motion apparently impeded as if forcing its way.	Id.
6	9 35 p.m.	Ibid	=2nd mag.*	Red	0·25 sec., rapid	From 105° −5° to 100 −7½	....	....	....	Another very similar meteor at right angles to it.	Id.
8	8 1 15 p.m.	Ibid	=3rd mag.*	Blue	0·7 second ...	From 105°+3½° to 100 +3½	Nearly disappeared in the middle of its course.	....	....	Eight other meteors in a short time seen before this one.	J. E. Clark and T. H. Waller.
22	9 56 p.m.	Ibid	=1st mag.*.........	White	1 sec., pretty slow.	From 113°+10° to 110 −2	....	8°...........	....	....	J. E. Clark.
24	9 25 p.m.	Ibid	=1st mag.*	Bright white...	0·25 second ...	From 80° +28° to 80 +27	....	5°...........	Directed from Mars ...	....	Id.
28	9 50 p.m.	Ibid	=1st mag.*.........	Bright blue ...	0·5 sec., rapid	From 105°+4° to 90 −0	....	17°	From Procyon.........	....	Id.
28	10 0 30 p.m.	Ibid	=1st mag.*	White	0·7 sec., slow	From 100°+0° to 95 −5	Left no train	5°...........	....	....	Id.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1867. Mar. 4	h m s 8 0 p.m.	Highlands of Scotland.	Brighter than Venus.	Bluish	1 sec., very quick.	Not far above the horizon.	Broke very distinctly into several small pieces, when it disappeared.	45°	horizon.		J. Clarke. Communicated by A. S. Herschel.
4	9 27 p.m.	York	=2nd mag.*	Bright blue	0·5 second	$\alpha=$ $\delta=$ From 60° −3° to 61 −8		5°	From Aldebaran	Fine clear night; stars extremely bright.	J. E. Clark.
5	7 48 p.m.	Ibid	=♀	Red	2½ secs., very slow.	From 44°+ 3¼° to 40 −10	Drew a tail of red sparks 1° long.	15°		At first equal 1st mag.*, then brightened up to its full size.	Id.
24	7 43 p.m.	Ibid	=Sirius	Red	2 seconds	From 230°+56° to 130 +60	Left a blue train gradually fading along its whole length together.	40°	From N.E. to zenith	Faded gradually	J. E. Clark and F. Bewley.
24	8 12 p.m.	Ibid	=2nd mag.*	Yellow	0·7 sec., slow.	From 200°+45° to 205 +42		4°			Id.
24	8 14 p.m.	Ibid	=2nd mag.*	White	1 sec., slow motion.	From 230°+56° to 290 +65					F. Bewley.
25	8 35 p.m.	Glasgow	=2nd mag.*	Orange yellow	2·7 seconds	From δ Ursæ Majoris to *m* Custodis.	Left no train or sparks		Directed from δ Virginis.		A. S. Herschel.
26	8 12 p.m.	York	=1st mag.*	Red	2 seconds	$\alpha=$ $\delta=$ From 145°+26½° to 176 +29	Left a red train 2¼° long.	22°			F. Bewley.
27	8 14 30 p.m.	Ibid	=3rd mag.*	White	0·2 sec., very rapid.	From 263°+45° to 256 +44		4°			J. E. Clark.
27	9 15 p.m.	Ibid	=1st mag.*	White	1 sec., rather slow.	From 110°+ 9° to 114 −14		15°			A. C. Marriage.
31	8 37 p.m.	Ibid	=1st mag.*	Yellow	0·4 second	From 121°+24° to 125 +20		4°			J. E. Clark.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1867. Mar. 31	h m s 9 14 30 p.m.	York	=3rd mag.*	White	0·2 sec., rapid	α= δ= From 123°+9° to 124 +7		2°			J. E. Clark.
31	9 15 p.m.	Ibid	=3rd mag.*	Yellow	0·2 sec., rapid	From 125° −3° to 125 −5		2°			Id.
Apr. 2	10 0 p.m.	Ibid	=1st mag.*	Red	2½ seconds, extremely slow.	From 153° −10° to 141 −14	Left a slight train			Brightened and faded away several times.	Id.
28	9 27 p.m.	Ibid	=1st mag.*	Yellow	0·25 sec., very rapid.	From 108° +15° to 104 +14		4°			Id.
29	10 30 to 11 45 p.m.	Prestwich, Manchester.	=1st mag.*	White	0·5 second	Zenith	Like a flash of rather diffused light.	2°	Radiant $M_{7,8}$, at η Ursæ Majoris.		R. P. Greg.
29		Ibid	=4th mag.*	Dull white	0·8 second	From ι Ursæ Maj. to α Telescopium.	No train		S G_2, Radiant?		Id.
29		Ibid	=5th mag.*	Dull white	0·4 second	To ½ (α, β Gemin.), halfway from ι Cancri.	No train	5°	Y or S_5, Radiant		Id.
29		Ibid	=4th mag.*	Dull white	1 second	From ε Virginis to λ Leonis.	No train		S_5, Radiant, at δ Virginis.		Id.
29		Ibid	=3rd mag.*	Dull white	0·75 second	From θ Leonis to c Leonis.	No train		$M_{7,8}$, Radiant		Id.
30	10 10 p.m.	Ibid	=3·5 mag.*	Dull white	0·5 second	From η Herculis to H Bootis.	No train		Y, Radiant?		Id.
May 1	11 18 p.m.	Ibid	=1st mag.*	White	0·5 second	At z Virginis	Bright flash of diffused light.	1°	S G_2		Id.
1	11 40 p.m.	Ibid	=2nd mag.*	White	0·5 second	From Y Herculis to x Bootis.			S_5 (6)		Id.
1	11 35 p.m.	Ibid	=6th mag.*		0·2 second	From θ Leonis to 48 Leonis.			$M_{7,8}$		Id.
1	11 30 p.m.	Ibid	=3rd mag.*		0·5 second	½ (ε, π) Virginis to ι Leonis.			S_5 (6)		Id.
1	11 46 p.m.	Ibid	=2½′ diameter	Bluish green	0·7 second	Commenced at ½ (π Leonis. f Sextantis).	Rocket-like	4°	Y, Radiant. Directed from θ Leonis.	Most beautiful; momentary train; brilliant.	Id.
1	11 to 12 p.m.	Ibid	=3rd mag.*	Dull white	½ second	Disappeared at π Herculis.		2°	Directed from α Lyræ, Radiant Q_1 (?).		Id.
1		Ibid	=1st mag.*	White	½ second	Disappeared at 110 Virginis.		1°	Radiant S G_2		Id.
1	12 20 a.m.	Ibid	=2nd mag.*	Bluish white	0·5 second	½ (λ, ι) Coronæ		2°	? Q_1		Id.
5	10 12 p.m.	Ibid	=1½ mag.*	Vivid white	1 second	From g Leonis Minoris to π Cancri.	Left a slight train		Radiant W.		Id.
5	10 24 p.m.	Ibid	=3rd mag.*	Reddish white	½ second	Disappeared at β Geminorum.		2°	Directed from γ Leonis; Radiant Y (?).		Id.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1867. May 5	h m 10 27 p.m.	Prestwich, Manchester.	=3rd mag.*	Dull white	½ second	From 61 Ursæ Majoris to δ Leonis.		4°	From Radiant $M_{7,8}$		R. P. Greg.
5	10 48 p.m.	Ibid	=1½ mag.*	Vivid white	1½ second	From *h* Ursæ Minoris nearly to ψ Cancri.	Left a train for 1 second		From Radiant W		Id.
6	7 50 p.m.	Regent's Park, London.	Two or three times as bright as Venus; very brilliant.			First appeared on the meridian about 15° N. of the zenith.	Clearly kite-shaped			In strong twilight; none of the brighter stars yet visible.	T. Crumplen.
7	11 0 p.m.	Manchester	=1½ mag.*	Bright white	½ second	From *e* to η Bootis.		1°	From Radiant S G_2		R. P. Greg.
7	11 5 p.m.	Ibid	=2nd mag.*	Reddish white	1 second	From W to β Virginis.	Left a slight train		From Radiant W		Id.
8	10 to 11 p.m.	Ibid								In one hour no meteors seen.	Id.
June 11	8 0 p.m. (Paris time.)	Paris	Great fireball	At first yellow, then bright green.		Disappeared in the N.N.E., altitude about 35°.	Drew a train of sparks and left a faintly luminous train after disappearance of the nucleus.	35°	Left to right, nearly horizontal.	A few minutes after sunset; seen in full daylight. The streak was seen for an hour at Basle and elsewhere. (See Appendix.)	J. J. Silbermann.
July 30	10 10 p.m.	Boulogne	=2nd mag.*	Orange red	1·8 second	Disappeared at β Leonis.	Drew a train of red sparks	15°	Directed from Lacerta	Disappeared gradually	A. S. Herschel.
30	10 30 p.m.	Straits of Dover	=2nd mag.*	White	1·5 second	From *u* Herculis to B Cerberi.	Left a train for ½ a second				Id.
30	10 57 p.m.	Ibid	=2nd mag.*	White	0·5 second	From σ to *h* Ursæ Majoris.	Left no train				Id.
30	11 0 p.m.	Ibid	=3rd mag.*	White	0·8 second	From β Lyræ to *p* Ophiuchi.	Nucleus a misty-looking object.				Id.
30	11 30 p.m.	Ibid	=3rd mag.*	White	0·4 second	From *n* Tarandi to ½ (M, P) Camelopardi.	Left a streak for ⅔ second				Id.
31	12 2 a.m.	Ibid	=2nd mag.*	Yellow	0·6 second	From α Lyræ to C Cerberi.	Left a very slight streak				Id.
31	12 9 a.m.	Ibid	=3rd mag.*	Yellow	0·5 second	From K, halfway to δ Herculis.	Left a slight train				Id.
31	12 20 a.m.	Ibid	=2nd mag.*	Bright white	0·7 second	From ½ (η, χ) to δ Cygni.	Left no train				Id.
31	12 25 a.m.	Ibid	=1st mag.*	White	1·6 second	From ε Cygni, halfway to α Cephei.	Disappeared suddenly, left no train.		Path crooked and oscillating at last.		Id.
31	12 30 a.m.	Ibid	=3rd mag.*	Yellow	0·5 second	Commenced at ε Aquilæ.	Left no train	12°	Directed from ε Delphini.		Id.
31	12 40 a.m.	Ibid	=3rd mag.*	Yellow	0 6 second	Commenced at ε Aquilæ.	Left no train	10°	Directed from Altair	Sixteen meteors in two hours and ten minutes; perfectly clear sky; no moon; one observer.	Id.
Aug. 2	10 30 to 12 0 p.m.	Prestwich, Manchester.	=2nd mag.*	White	0·5 second	From *y* Ursæ Majoris to near *d* Bootis.	Left a train		From Radiant A_0		R. P. Greg.
6		Ibid	=3rd mag.*	White	0·2 second	From σ to *o* Herculis.			From Radiant A_0		Id.
6		Ibid	=2nd mag.*	White	0 25 sec., rapid	From ε Aquilæ to *x* Tauri Poniatovii.			From Radiant A_0		Id.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1867. Aug. 6	h m	Prestwich, Manchester.	=3rd mag.*	White	0·2 second ...	From α Aquarii to ½ (τ, β) Pegasi.	Left a train	....	From Radiant A_0	....	R. P. Greg.
7	....	Ibid	=2nd mag.*	Bright white...	0·25 second ...	From η Herculis to near π Serpentis.	....	....	From Radiant B_3 (?) ...	....	Id.
7	....	Ibid	=3rd mag.*	Dull	0·3 second ...	From ρ Aquilæ to 18 Aquilæ.	....	....	From Radiant $T_{1, 2}$ ...	....	Id.
7	....	Ibid	=3rd mag.*	Dull	0·3 second ...	From μ Delphini, three-quarters of the way to γ Aquilæ.	....	....	From Radiant $T_{1, 2}$.	....	Id.
7	....	Ibid	=1½ mag.*	White	0·4 second ...	Close to α_1 Capricorni.	....	2°	From Radiant $T_{1, 2}$ (?)...	....	Id.
7	....	Ibid	=2nd mag.*	White	0·75 second ...	From ½ (g, e) Pegasi to λ Honorum.	Left a train	....	From Radiant A_0	....	Id.
7	....	Ibid	=1½ mag.*	White	0·75 second ...	From γ Trianguli towards Aries.	Left a train	10°	Directed from γ Persei. From Radiant A_0.	....	Id.
7	10 30 to 12 0 p.m.	Ibid	=3rd mag.*	....	0·2 sec., rapid	From e Cephei to α Sagittæ.	....	....	From Radiant A_0	....	Id.
7	....	Ibid	=1st mag.*	Bluish white...	1 second	From I Aquilæ to ν Andromedæ.	Left a train for 3 seconds.	....	From Radiant A_0	....	Id.
7	....	Ibid	=1½ mag.*	Reddish white	1·5 second ...	From η Pegasi to ξ Andromedæ.	....	....	Opposite in direction to the last.	Slower than the previous meteor.	Id.
7	....	Ibid	=3rd mag.*	....	0·2 sec., very rapid.	From (½ β, λ) Pegasi to λ Honorum.	....	....	From Radiant A_0	The rapid meteors of the chief August shower radiate rather from ε Cassiopeiæ than from γ Persei.	Id.
8	10 42 p.m.	Birmingham ...	=2nd mag.*	White	0·5 second ...	α= δ= From 103°+77° to λ Draconis.	....	....	Directed from C Camelopardi.	One-half of the sky overcast.	W. H. Wood.
8	11 41 p.m.	Ibid	=3rd mag.*	Blue	0·5 second ...	From ε Ursæ Majoris to Cor Caroli.	....	....	Directed from ε Cassiopeiæ.	Seven-tenths of the sky cloudy.	Id.
8	12 0 p.m.	Ibid	=1st mag.*	White	0·5 second ...	α= δ= From 270°+15° to 263 − 3	Left a train	....	Directed from ε Cassiopeiæ.	Sky clearing	Id.
9	12 8 a.m.	Ibid	=3rd mag.*	Blue	0·5 second ...	From ε Aquilæ to η Serpentis.	....	....	Directed from ε Cassiopeiæ.	....	Id.
9	12 22 a.m.	Ibid	=1st mag.*	Yellow	0·3 second ...	From ζ Draconis to γ Ursæ Minoris.	....	....	Directed from α Lyræ...	Sky clear	Id.
9	12 30 a.m.	Ibid	=2nd mag.*	Blue	0·75 second ...	α= δ= From 124°+61° to δ Ursæ Majoris.	Left a train	....	Directed from C Camelopardi.	....	Id.
9	12 31 a.m.	Ibid	=2nd mag.*	White	0·75 second ...	α= δ= From 108°+50° to κ Ursæ Majoris.	....	....	Directed from ε Persei...	No other meteor seen till 1^h a.m.	Id.
9	10 30 to 12 0 p.m.	Prestwich, Manchester.	=1½ mag.*	White	0·5 second ...	From ½ (γ, δ) Ursæ Majoris, halfway to d Canum Venaticorum.	....	....	From Radiant A_0	....	R. P. Greg.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Aug. 9	h m s	Prestwich, Manchester.	$=1\frac{1}{2}$ mag.*	White	0·3 second	From δ Ursæ Majoris to Cor Caroli.			From Radiant A_0		R. P. Greg.
9		Ibid	=3rd mag.*			From θ to ρ Bootis.			From Radiant A_0		Id.
9		Ibid	=2nd mag.*	White	0·5 second	From *d* Custodis to T Cephei.	Left a train		From Radiant A_0, or $N_{11, 12}$ (?). Moved towards Perseus.		Id.
9		Ibid	=3rd mag.*	Dull	0·75 second	From α Pegasi to ξ Cygni.			From Radiant $T_{1, 2}$		Id.
9		Ibid	=2nd mag.*	Bright white	0·25 second	From η Herculis to π Serpentis.	Left no train		From Radiant B_3		Id.
9		Ibid	$=1\frac{1}{2}$ mag.*	Bluish white	0·75 second	From α Pegasi to ν Andromedæ.	Left a train		From Radiant A_0		Id.
9	10 30 to 12 0 p.m.	Ibid	$=1\frac{1}{2}$ mag.*		0·75 second	From ι Pegasi to α Andromedæ.	Left a train		From Radiant A_0		Id.
9		Ibid	=2nd mag.*		0·4 second	From β Aquarii to θ Andromedæ.	Left a train		From Radiant A_0		Id.
9		Ibid	$=1\frac{1}{2}$ mag.*		$\frac{3}{4}$ second	Centre at *c* Andromedæ.		1°	Directed from γ Persei. Radiant A_0.		Id.
9		Ibid	=3rd mag.*			Centre at $\frac{1}{2}$ (*c*, γ) Trianguli.		3°	Directed from λ Persei. Radiant A_0.		Id.
9	10 9 p.m.	Birmingham	=Sirius	Yellow	0·5 second	From φ to β Andromedæ.			Directed from ε Cassiopeiæ.	From 9^h to 10^h p.m., sky clear; no meteors seen.	W. H. Wood.
9	11 32 p.m.	Ibid	=1st mag.*	Blue	0·5 second	From η Persei to φ Andromedæ.	Left a train		Directed from *c* Camelopardi.	Two meteors seen in 1^h 30^m.	Id.
9	11 45 p.m.	London	$=2\frac{1}{2}$ mag.*	Pale blue		α= δ= From 39° $+68\frac{1}{2}$° to 24 +57				These two meteors from the same Radiant nearly simultaneous.	T. Crumplen.
9	11 46 p.m.	Ibid	Almost = ♃	Pale blue		From 27 +68 to $13\frac{1}{2}$ $+52\frac{1}{2}$	Left a fine blue streak on its whole course.				Id.
9	11 46 p.m.	Birmingham	=Sirius	Orange	0·75 second	From 33 +60 to ν Andromedæ.	Left a train of sparks		From Radiant *c* Camelopardi.	(See Appendix I.)	W. H. Wood.
9	11 53 p.m.	Ibid	=3rd mag.*	Blue	0·75 second	From α Persei to δ Aurigæ.	Left a train				Id.
9	11 53 30 p.m.	Ibid	=3rd mag.*	Blue	0·5 second	From δ Aurigæ α= δ= to 108°+52°			From Radiant C Camelopardi.		Id.
9	11 55 p.m.	Ibid	Brighter than ♃	Blue	2·5 seconds	From 16°+72° to κ Aurigæ.	Increased from 2nd magnitude star to the apparent size of Jupiter, changing from round to pear-shaped. Anterior part silvery white, body blue. Left a phosphorescent streak on its whole course for 3 or 4 seconds.		Directed from β Cephei		Id.
10	12 4 a.m.	Ibid	=Sirius	Orange-colour	0·5 second	α= δ= From 50°+ 37° to Pleiades.	Left a train		Directed from ε Cassiopeiæ.		Id.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1857. Aug. 10	h m s 12 10 a.m.	Birmingham	=2nd mag.*	Blue	0·5 second	From γ Andromedæ to α= 21° δ= + 22°			Directed from l Camelopardi.		W. H. Wood.
10	12 21 a.m.	Ibid	=2nd mag.*	Blue	0·5 second	From α to θ Pegasi.			Directed from ε Persei.		Id.
10	12 46 a.m.	Ibid	=2nd mag.*	Blue	0·5 second	From β Persei to α= 48° δ= + 23°			Directed from ε Cassiopeiæ.		Id.
10	12 46 30 a.m.	Ibid	=2nd mag.*	Blue	0·2 second	From α to ν Persei			Directed from ε Cassiopeiæ.		Id.
10	12 52 a.m.	Ibid	Brighter than 1st mag.*.	Orange colour	0·5 second	α= δ= From 10°+60° to 332 +48	Left a train		Directed from C Camelopardi.		Id.
10	12 59 a.m.	Ibid	=1st mag.*	Yellow	1 second	From 70 +60 to 94 +59			Directed from C Camelopardi.		Id.
10	1 0 a.m.	Ibid	=3rd mag.*	Blue	0·5 second	From 67 +66 to 120 +60			Directed from l Camelopardi.		Id.
10	1 10 a.m.	Ibid	=1st mag.*	Yellow	0·5 second	From 97 +60 to κ Ursæ Majoris.	Left a train		Directed from C Camelopardi.		Id.
10	1 22 a.m.	Ibid	=1st mag.*	Orange	0·75 second	From ν Persei to α= 67° δ= + 28°	Left a pale green train		Directed from γ Cassiopeiæ.	At $1^h 30^m$ a.m. rate 14 meteors per hour.	Id.
10	9 39 p.m.	London	=2½ mag.*			α= δ= From 58° +78½° to 17 +63					T. Crumplen.
10	9 57 p.m.	Ibid	=2½ mag.*	...		From 275 +83 to 322 +64				Followed by another with bright streak more to the right.	Id.
10	10 5 30 p.m.	Ibid	=3rd mag.*			From 97½ +73½ to 53 +65½					Id.
10	10 11 p.m.	Ibid	=1st mag.*	Bright orange colour.		From 102 +26½ to 150 +37	Left a short train which faded quickly.			Ended beyond the boundary of the map. Two bright globular meteors remarkably alike.	Id.
10	10 11 15 p.m.	Ibid	=1st mag.*	Bright orange colour.		From 18½ +39½ to 15½ +29½	Left a short train which faded quickly.				Id.
10	10 16 p.m.	Ibid	=2nd mag.*			From 317 +57½ to 5 +65			From Radiant, near α Lyræ.		Id.
10	10 28 p.m.	Ibid	=2½ mag.*			From 357 +18½ to 356½ +10½				A 2nd mag. meteor preceded this one from near α Lyræ.	Id.
10	10 36 p.m.	Ibid	=3rd mag.*			From 340 +28½ to 2½ +15			From Radiant, near α Lyræ.		Id.
10	10 43 p.m.	Ibid	=1½ mag.*	Pale blue		From 352½ +66 to 351 +41					Id.
10	10 48 p.m.	Ibid		Pale blue		From 20 +70½ to 4 +50					Id.
10	10 56 p.m.	Ibid	=2nd mag.*			From 17 +52 to 12 +37					Id.
10	10 57 p.m.	Ibid	=1st mag.*	Pale blue		Disappeared near α Coronæ.				Imperfect view. Identical with the next. (See Appendix I, 8.)	Id.
10	10 57 p.m.	Birmingham	=1st mag.*	Yellow	1 second	From γ Cygni to ε Aquilæ.			Directed from ε Cassiopeiæ.	Tortuous path; sky eight-tenths clouded.	W. H. Wood.
10	11 13 p.m.	Ibid	=3rd mag.*	Blue	0·5 second	From ζ Cygni to γ Equulei.			Directed from Polaris.	From 9^h to 10^h p.m. no meteors seen; clear sky.	Id.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Aug. 10	h m 11 36 p.m.	Birmingham	=1st mag.*	Blue	0·5 second	α= δ= From 57° + 45° to 90 + 62			Directed from ν Persei.		W. H. Wood.
10	11 45 p.m.	Ibid	=3rd mag.*	Blue	0·5 second	From β Andromedæ to δ Piscium.			Directed from ε Cassiopeiæ.	Sky four-tenths clouded round the horizon.	Id.
10	11 55 p.m.	Ibid	Brighter than Sirius	Yellow	1·5 second	From γ Cephei to ι Draconis.	Left a green train on its whole course for three seconds.		Directed from ε Cassiopeiæ.		Id.
10	11 56 p.m.	Ibid	=2nd mag.*	Blue	0·5 second	α= δ= From 25°+71° to ι Cephei.			Directed from c Camelopardi.		Id.
10	11 58 p.m.	Ibid	=3rd mag.*	Blue	0·5 second	From 25°+71° to γ Cephei.			Directed from B Camelopardi.		Id.
11	12 16 a.m.	Ibid	Brighter than 1st mag.*.	Orange-colour	0·5 second	From φ to μ Andromedæ.	Left a train		Directed from c Camelopardi.	Sky (round the horizon) two-tenths clouded.	Id.
11	12 45 a.m.	Ibid	=2nd mag.*	Yellow	0·5 second	From α Andromedæ to γ Piscium.			Directed from ε Cassiopeiæ.	No meteors seen in the last interval.	Id.
11	12 48 a.m.	Ibid	=2nd mag.*	Yellow	0·5 second	From β Andromedæ α= δ= to 11° + 14°			Directed from ε Cassiopeiæ.		Id.
11	12 54 a.m.	Ibid	=1st mag.*	Blue	1·25 second	From ν Persei to α Aurigæ.			Directed from ν Persei.		Id.
11	12 55 a.m.	Ibid	=1st mag.*	Blue	1·25 second	From Pleiades to α= δ= 72° + 23°			Directed from γ Pegasi		Id.
11	12 59 a.m.	Ibid	=1st mag.*	Blue	0·75 second	From γ Pegasi to α= δ= 350° − 6°			Directed from c Camelopardi.		Id.
11	1 11 a.m.	Ibid	=2nd mag.*	Blue	0·5 second	From μ to ζ Persei			Directed from c Camelopardi.	At 1^h 20^m a.m. sky hazy; stars scarcely visible.	Id.
11	11 8 p.m.	Ibid	=3rd mag.*	Blue	0·5 second	From η to α Herculis.			Directed from q Camelopardi.	Fine moonlight night	Id.
11	11 14 p.m.	Ibid	=1st mag *	Blue	0·75 second	α= δ= From 70°+60° to 100 +64	Left a train		Directed from γ Persei.	Three meteors per hour	Id.
11	11 47 p.m.	Ibid	=2nd mag.*	Orange colour	0·75 second	From 67 +66 to 78 +69	Left a red train		Directed from c Camelopardi.		Id.
12	12 5 a.m.	Ibid	Brighter than 1st mag.*.	Blue	0·75 second	From β Persei to α= δ= 41° + 32°	Left a train		Directed from C Camelopardi.		Id.
12	From 10 to 11 p.m.	Prestwich, Manchester.	=2nd mag.*	White	0·4 second	From β Cassiopeiæ to α Cephei.	Left a train		From Radiant A_0 (?)		R. P. Greg.
12		Ibid		Dull reddish	0·5 second	From φ Cephei to m Custodis.			Directed from Radiant B_3.		Id.
12		Ibid	=2nd mag.*	White	0·25 second	From λ Draconis to δ Ursæ Majoris.	Left a train		From Radiant A_0		Id.
12		Ibid	=2nd mag *	White	0·5 second	From σ Cassiopeiæ.	Left a train		From Radiant B_3 (?)		Id.
12		Ibid	=2nd mag.*			Centre at ⅓ (c, γ) Trianguli.	Left a train	2°	Directed from λ Persei. From Radiant A_0.		Id.
12		Ibid	=3rd mag.*		0·5 second	Centre at ι Persei		3°	From Radiant A_0		Id.
12		Ibid	=2nd mag.*		0·3 second	Centre at φ Ursæ Majoris.	Left a train		From Radiant A_0	Moon nearly full; fine night.	Id.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.	Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
1866. Aug. 12	h m s 9 3 p.m.	Birmingham ...	=1st mag.*	Blue	1 second	From α Pegasi to β Aquarii.	....	....	Directed from γ Persei..	Fine moonlight night ...	W. H. Wood.
12	11 37 p.m.	Ibid	=2nd mag.*	Blue	0·5 second ...	α= δ= From 121°+62° to φ Ursæ Majoris.	....	....	Directed from C Camelopardi.	Meteors two per hour; one observer.	Id.
19	10 0 p.m. (local time).	Palisades, Dobb's Ferry, U. S. A.	Appeared several times larger than Jupiter.	Blue, then lilac	2 or 3 seconds	Appeared about midway between α Lyræ and η Ursæ Majoris, between the body of Draco and the feet of Hercules.	Irregular globular mass, rather elongated in the direction of its flight; roughly divided into at least two, probably three, parts, like a mass of molten iron from a ladle. At first surrounded by bright coruscations; subsequently by a pale ruddy lilac glare, and then disappeared.	2° or 3° while in sight.	Moved along a line drawn from α Lyræ to η Ursæ Majoris.	Seen apparently at the close of its flight. The observer's attention called to it by a blue flash of light.—Seen also at New London, Conn. Yellow, surrounded by blue and green light. Roughly globular; elongated in the direction of its fall. Altitude 45°.	W. S. Gilman, jun.; N. Y. Tribune.
20	About 8 25 p.m.	Hawkhurst (Kent).	As bright as Jupiter	Colour of Jupiter.	1·3 second ...	From δ to η Andromedæ.	Brightest near the middle of its path. No train or sparks.	10°	Nearly perpendicular; downwards.	Light slightly interrupted at small intervals.	A. S. Herschel.
20	9 0 p.m.	Ibid	=2nd mag.*	White	1 second	Commenced at h Lyncis.	Brightest near the middle of its path.	8°...........	Directed from P Camelopardi.	....	Id.
20	9 5 p.m.	Ibid	=2nd mag.*	White	1 second	From δ Andromedæ to φ Piscium.	No train or sparks	....	....	....	Id.
Sept. 1	7 59 30 p.m.	Greenwich	Two or three times brighter than a 1st mag.*.	Greenish white	1·5 second ...	From altitude 35° to altitude 10°, about 20° W. of N.	Rather less bright at first, when it was seen through a slight veil of cloud.	....	Vertically down	Sky cloudy. The meteor disappeared and reappeared behind the clouds.	H. Airy.

APPENDIX.

Observations of Meteors made at the Cambridge Observatory between November 13th, $11^h\ 30^m$ and November 13th, $14^h\ 15^m$, in the year 1866. By Professor CHALLIS.

The observations were made by means of a small wooden meteoroscope on a tripod stand, furnished with a straight bar about 21 inches long, and readily moveable in altitude and azimuth. The movement in altitude carried a graduated arc which was read off by an index partaking of the azimuth motion. The movement in azimuth carried a horizontal graduated circle read off by an index fixed to the tripod stand. I marked the lines of graduation roughly to integral degrees for use on this occasion. In taking an observation, the bar was pointed by hand to the place of the meteor, the eye looking along the straight edge. The point selected for observation was sometimes the middle of the course, but more generally the end of it. At the instant of seeing the meteor I called out "now," and Mr. Todd, the Junior Assistant at the Observatory, gave the time from a mean-time chronometer from which he was counting to himself. I then took the altitude- and azimuth-readings, which, with the time and the other circumstances, were recorded by H. Wilberforce Clarke, Esq., R.E., of Chatham. The direction of flight was estimated by conceiving the face of a watch to be projected on the heavens, its centre coinciding with the observed place of the meteor, and the hour XII pointing towards the zenith. The meteor's course was in the direction from the centre of the watch towards the recorded hour. No especial care was taken to place the axis of motion of the meteoroscope in a vertical position, but I had previously adjusted the lengths of the legs of the stand so that if it were placed on a horizontal plane the axis would be very nearly vertical. From time to time altitude and azimuth observations were taken of stars, for the purpose of obtaining data for calculating the error of position of the axis. The stand was placed on the flat roof of a small outbuilding, covered somewhat unevenly with lead, and not being attached to the roof and being of light weight, it was liable to be shaken and displaced. I have reason to say that in consequence of accidental disturbance, it did not retain exactly the same position during the whole of the observations. With regard to magnitude, the meteors are divided into three classes called α, β, and γ. Those of class α were as bright as stars of the first magnitude, and a few as bright as Venus when brightest. The class β were of the second or third magnitude; and the class γ were compara-

tively faint, but not smaller than fifth-magnitude stars. The letter T in the subjoined list indicates that the meteor had a train, which was the case with by far the greater number. Observations were made at the same time and place with another meteoroscope by Professor Adams and his Senior Assistant Mr. Graham, and it was agreed to divide the heavens into the northern and southern halves. As I took the northern half, my observations are principally in that portion, the exceptions occurring in the earlier and later observations, and when the north quarter was nearly covered with clouds. (See Table, pp. 364, 365.)

Notes explanatory of the Calculations.

The chronometer was $2^m\ 51^s{\cdot}82$ fast on Observatory Mean Time at November 13th, $11^h\ 28^m$, and $2^m\ 52^s{\cdot}35$ fast at November 13th, $16^h\ 49^m$. Hence as the Observatory is $22^s{\cdot}75$ east of Greenwich, $3^m\ 15^s$ has been subtracted from each of the chronometer times to calculate the Greenwich Mean Time to the nearest second. The azimuths are reckoned from the N. point through E. to 360°. Let A represent the azimuth-reading, and z the zenith-distance reading for any star, and let a and ζ be its true azimuth and zenith distance calculated from its known R. A. and N. P. D., the colatitude of the Observatory being 37° 47′, and the longitude east $22^s{\cdot}75$. Also suppose the axis of the instrument to have inclined by the arc x from the zenith towards the south, and by the arc y from the zenith towards the east. Then if m be the index-correction of the zenith-distance readings, and n the index-correction of the azimuth-readings, we have the following equations:—

$$\zeta - Z = m - x\cos a + y\sin a,$$
$$a - A = n + \cot\zeta\,(x\sin a + y\cos a).$$

The values of A, Z, a and $90° - \zeta$ are given in the foregoing Table. By using these values, two equations were derived from each of the observations of stars. It should, however, be stated that, instead of using the recorded value of z, I have adopted in each instance a value *greater* by one-fourth of a degree, having found by experiment that the eye was almost necessarily elevated a little above the end of the bar in order to see the opposite end in coincidence with the object. The experiments gave a difference of pointing equal to about 15′. Also the small correction required for refraction has been taken into account to the nearest minute. In this manner the following equations were obtained for determining the values of m, n, x and y:—

No. of the Series.	($\zeta - Z$)		No of the equation.	($a - A$)		No. of the equation.
1.	21°27′*	$= m - 0{\cdot}0465x + 0{\cdot}9989y$	(1)..	−52°10′	$= n + 0{\cdot}8466x + 0{\cdot}0394y$	(8)
3.	21 25	$= m + 0{\cdot}6494x + 0{\cdot}7604y$	(2)..	−53 0†	$= n + 0{\cdot}5337x - 0{\cdot}4559y$	(9)
22.	17 11	$= m - 0{\cdot}8650x - 0{\cdot}5018y$	(3)..	−56 37	$= n - 0{\cdot}0634x + 0{\cdot}1093y$	(10)
46.	21 21	$= m + 0{\cdot}2230x + 0{\cdot}9748y$	(4)..	−53 7	$= n + 1{\cdot}2205x - 0{\cdot}2791y$	(11)
51.	20 51	$= m + 0{\cdot}0311x + 0{\cdot}9995y$	(5)..	−54 13	$= n + 0{\cdot}3123x - 0{\cdot}0097y$	(12)
62.	19 41	$= m + 0{\cdot}7755x + 0{\cdot}6314y$	(6)..	−55 9	$= n + 0{\cdot}4766x - 0{\cdot}5854y$	(13)
70.	19 56	$= m + 0{\cdot}2275x + 0{\cdot}9738y$	(7)..	−53 51	$= n + 0{\cdot}4704x - 0{\cdot}1099y$	(14)

Any displacement of the stand would be likely to exhibit itself in discordances of the values of $a - A$, rather than in discordant values of $\zeta - Z$. The above values of $a - A$ show that there was no azimuthal change sufficient to affect the values of x and y, but that there may have been small changes of the index-correction n. These changes, must, however, have been too small to have any perceptible effect on the values of $\zeta - Z$. As there was an interval of only three minutes between Nos. 1 and 3, it may be assumed that for these observations both m and n had the same values. Accordingly, after eliminating m and n from the equations (1), (2), (8) and

* Instead of the recorded reading 32° I have used 28°, an error having been apparently committed by mistaking the direction of the graduation.

† Instead of the azimuth-reading 188½ I have adopted 183½, a mistake having been probably made in reading off or recording.

(9), the resulting two equations have been employed for finding x and y. These equations are—

$$-\ 2'=0{\cdot}6959x-0{\cdot}2385y,$$
$$+50'=0{\cdot}3129x+0{\cdot}4953y,$$

which give $x=+26'$, $y=+84'$. As I had no reason to suspect any azimuthal disturbance of the instrument between Nos. 62 and 70, the interval between them being not more than seventeen minutes, I have similarly employed the equations (6), (7), (13), and (14) for finding x and y. The two resulting equations are—

$$-15'=0{\cdot}5480x-0{\cdot}3424y,$$
$$-78'=0{\cdot}0062x-0{\cdot}4755y,$$

which give $x=+76'$, $y=+165'$. These values are not accordant with those obtained from the other set of equations; but perhaps the deviations from the mean values, which do not exceed 25′ in altitude and 40′ in azimuth, are not greater than what might be expected from the mode of observing and the character of the instrument. I have therefore adopted the values $x=50'$, $y=125'$, using 50′ instead of the exact mean 51′ for facility of calculation. I tried other combinations of the equations, but found none that gave as probable results as those derived from the above values of x and y.

Hence the values of n derived from the equations (8) and (9) are $-52°\ 57'$ and $-52°\ 30'$, the mean of which, $-52°\ 44'$, is adopted for Nos. 1 to 17 of the series, a note having been made that just after No. 17 the stand was disturbed. The values of n, similarly derived from the equations (10) to (14), are $-56°\ 47'$, $-53°\ 33'$, $-54°\ 27'$, $-54°\ 20'$, and $-54°\ 1'$. The two first seem to indicate unsteadiness of the stand, but as their mean does not greatly differ from the mean of all, it was thought right to adopt the latter mean, viz. $-54°\ 37'$, for all the observations after No. 17.

When the same values of x and y are substituted in the equations (1) to (7), the resulting values of m are 19° 24′, 19° 17′, 18° 57′, 19° 7′, 18° 44′, 17° 43′, and 17° 43′, the mean of which is 18° 42′. For verification of this result I also obtained the index-correction in the following manner:—An adjusted spirit-level was placed on the upper flat side of the bar, and the bar being made to point horizontally by bringing the bubble into middle position, the altitude-circle was read off. The same thing was done after changing the azimuth by 180°. The two readings being 71° 15′ and 71° 35′, the complement of half their sum is +18° 35′, which consequently is the index-correction. By another trial made in azimuths 90° from the former, the two readings were 70° 0′ and 73° 0′, and the index-correction is consequently +18° 30′. The mean between the two results, viz. 18° 33′, is the adopted value of m; this mode of determining it being thought to be more accurate than the other. The small difference between this value and +18° 42′ is considerable confirmation of the accuracy of the adopted values of x and y. It should be added that in obtaining these corrections, the meteoroscope was placed, as nearly as could be conjectured after about a month's interval, in the same position that it had during the observations, and that consequently the values of x and y may be inferred from the differences of the altitude-readings in the respective positions. The values thus obtained are $x=+10'$, $y=+90'$. As I could not be sure that the meteoroscope in this trial had exactly the same position as before, I have preferred using the values of x and y deduced from the observations of stars.

Representing now by A and Z the azimuth- and zenith-distance readings for the observation of any meteor, the following equations were employed for calculating its true azimuth and altitude as given by the observation:—

$$\text{True altitude } (\beta)=71°\ 12'-Z+50'\cos(A+n)+125'\sin(A+n)-\text{refraction}.$$
$$\text{True azimuth } =A+n+\tan\beta\,(50'\sin(A+n)+125'\cos(A+n)).$$

The value of n is $-52°\ 44'$ for Nos. 1 to 17, and $-54°\ 37'$ for the remaining Nos. The constant 71° 12′ is 90°−18° 33′−15′; the correction −15′ being applied for

Meteor Observations, November 13th, 1866.

No. of the Series.	Chronometer Time.	Azimuth-Reading.	Zenith-Distance Reading.	Direction-Hour.	Magnitude.	Train.	Greenwich Mean Time of observation	Calculated Azimuth from N. through E.	Calculated Altitude.	Calculated Direction-Angle.
	h m s	°	°	h			h m s	° ′	° ′	°
1.	11 40 51	139½	32	...	...	...	11 37 36	87 33	41 8	...
								(87 20)	(40 17)	
2.	42 47	178½	38	2¼	β	T	39 32	125 27	31 0	82
3.	44 0	188½	33¼	...	...	...	40 45	130 16	35 48	...
								(130 30)	(35 4)	
4.	49 2	271½	35½	3½	β	T	45 47	217 30	36 20	105
5.	56 48	10½	26¼	...	β	T	53 33	318 49	46 57	...
6.	11 56 53	26½	70	...	α	...	53 38	333 51	2 37	270
7.	12 0 56	46½	68¾	...	β	...	11 57 41	353 54	3 17	270
8.	3 22	345	55	9	β	T	12 0 7	292 16	18 24	270
9.	4 26	108	30	9	β	T	1 11	56 51	39 57	270
10.	5 47	19½	61	9¼	α	T	2 32	326 56	11 58	278
11.	8 19	325	17¾	8	γ	T	5 4	271 10	55 33	240
12.	10 19	121	20¾	12	β	T	7 4	70 3	48 48	360
13.	11 58	21	24	8½	β	T	8 43	329 49	48 59	255
14.	13 8	75½	50	9	β	T	9 53	23 39	21 7	270
15.	....	73	59	9½	α	T	....	20 46	12 12	285
16.	15 39	114	63½	9¼	α	...	12 24	61 28	6 8	278
17.	17 7	328	55	8	β	T	13 52	275 3	18 18	240
18.	18 40	66	27¼	9¾	β	T	15 25	13 33	44 20	292
19.	19 37	327	48	8	α	T	16 22	272 1	25 17	240
20.	21 39	88½	47	9	β	T	18 24	34 52	23 42	270
21.	22 41	74	0	9¾	β	T	19 26	26 5	71 18	292
22.	25 19	26½	65¼	...	...	...	22 4	332 3	7 36	...
								(329 53)	(7 12)	
23.	26 11	47½	50¾	8¾	β	T	22 56	353 40	21 30	263
24.	27 21	148	0—	1	β	T	24 6	95 14	69 4+	30
25.	28 49	347	16½	9½	γ	...	25 34	292 24	52 26	285
26.	30 1	47	42½	9	β	T	26 46	353 31	29 46	270
27.	31 36	88	47½	9¼	γ	T	28 21	34 20	23 13	278
28.	32 22	31½	28	8½	β	T	29 7	338 28	44 46	255
29.	33 52	63	10¾	10	α	T	30 37	12 21	60 57	300
30.	34 57	80	45	8¾	β	T	31 42	26 29	26 1	262
31.	36 19	84½	39	...	β	T	33 4	31 17	31 51	...
32.	37 35	140	31	12	γ	T	34 20	86 11	38 10	360

Remarks.

No. 1. The object was Castor. The azimuths and altitudes in brackets in the case of star-observations, were calculated from their known R. A. and N. P. D. Those not in brackets were calculated just as for meteor-observations. See the explanatory Notes.

No. 3. The star was α Orionis. See the remarks to No. 1.

No. 5. Taken at the end of the course. Direction-angle not observed.

No. 6. Skirting the horizon. The time is uncertain.

No. 7. Skirting the horizon. The direction-angles in this No. and the preceding one are inferred from this indication of the course. Both motions were westward.

No. 8. At the end of the course.

No. 12. At the end of the course.

No. 13. Middle of the course.

No. 15. The time was not recorded. A bright one followed quickly after.

No. 16. No train visible.

No. 17. After this No., the stand of the meteoroscope was accidentally disturbed.

No. 21. The direction-angle 9¾ is uncertain. Another came at the same time.

No 22. The object was α Lyræ.

No. 23. Place of vanishing.

No. 24. Passed nearly through the zenith. The altitude could not be reached by the meteoroscope, which did not admit of pointing to zenith distance less than 18½°.

No. 29. Vanishing-point.

No. 31. Direction-angle not observed.

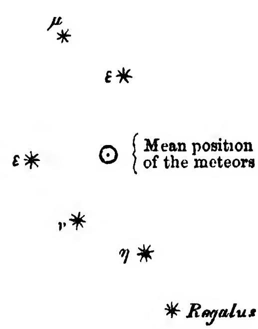
No. 37. The zenith-distance reading is assumed to be a mistake for 25. Compare No. 44.

33.	38 33	125	32	$11\frac{1}{2}$	β	T	35 18	71 32	37 30	345	No. 38. End of the course.
34.	39 34	19	58	$8\frac{3}{4}$	β	T	36 19	324 43	15 1	262	No. 39. Direction not noted.
35.	41 0	329	24	$7\frac{3}{4}$	β	T	37 45	273 36	49 19	232	No. 40. The magnitude is called α, β when it was doubtful whether it was of the first or second class.
36.	42 7	68	22	9	β	T	38 52	16 0	49 31	270	
37.	43 9	343	75	$7\frac{1}{2}$	β	T	39 54	288 14	48 25	225	
38.	43 52	90	42	$9\frac{1}{2}$	α	T	40 37	36 35	28 38	285	No. 42. At the middle of the course. The zenith distance of the end was out of the reach of the instrument. See No. 24.
39.	44 51	101	17	...	β	T	41 36	49 9	53 15	...	
40.	45 35	66	37	$9\frac{1}{4}$	α, β	T	42 20	12 55	34 35	278	
41.	46 26	100	21	$10\frac{1}{4}$	β	T	43 11	47 47	49 17	323	No. 43. The direction-hour must be a mistake for $6\frac{1}{2}$, none of the observed meteors having moved directly *towards* the Radiant-point.
42.	47 5	134	0–	12	α, β	T	43 50	82 34	69 18+	360	
43.	48 37	325	18	$0\frac{1}{2}$	α, β	T	45 22	269 12	55 16	195	
44.	50 6	352	25	$7\frac{1}{2}$	β	T	46 51	297 38	48 25	225	No. 46. The object was Castor.
45.	51 26	70	39	$8\frac{1}{4}$	β	T	48 11	16 48	32 25	248	No. 49. A slight train. At this time the northern part of the heavens was clouded. Shortly after, cloud spread over the whole, and the observations were interrupted.
46.	53 35	156	17	...	...	...	50 20	101 49	51 58	...	
								(102 53)	(51 23)		
47.	54 39	22	8	$8\frac{3}{4}$	α, β	T	51 24	330 10	65 0	262	
48.	56 30	92	36	$7\frac{1}{2}$	γ	T	53 15	38 53	34 35	225	No 50. The mean of the positions of two which appeared for an instant stationary, and came nearly at the same time; the time is doubtful. See the Notes respecting this time and the next.
49.	12 58 40	213	32	3	β	...	12 55 25	157 7	37 38	90	
50.	13 20 0	$137\frac{1}{2}$	44	...	...	...	13 16 45	83 24	25 12	...	
51.	21 0	146	$51\frac{1}{3}$	...	...	...	17 45	91 37	17 32	...	
								(91 47)	(17 21)		No. 51. The object was Regulus.
52.	41 16	119	$50\frac{1}{4}$	$7\frac{3}{4}$	β	T	38 1	64 58	19 23	232	No. 52. The train was blue or green; the meteor was ruddy. (The observations were slackened on account of the great number of meteors and the little probability that the same meteor would be observed at different places.)
53.	44 14	22	$12\frac{3}{4}$	8	β	T	40 59	329 40	60 16	240	
54.	45 28	61	35	9	β	T	42 13	8 0	36 47	270	
55.	46 4	$102\frac{1}{2}$	18	$8\frac{1}{2}$	β	T	42 49	50 29	52 12	255	
56.	48 8	140	$51\frac{1}{3}$	$6\frac{1}{4}$	β	T	44 53	85 42	17 38	188	
57.	50 23	139	30	$11\frac{3}{4}$	β, γ	T	47 8	85 14	39 12	353	No. 56. Below the Radiant-point.
58.	53 7	271	45	$3\frac{3}{4}$	α, β	T	49 52	215 17	26 44	112	No. 57. Above the Radiant-point.
59.	56 50	276	58	4	β	...	53 35	220 52	13 53	120	No. 59. No train.
60.	57 36	243	34	4	α, β	...	54 21	186 52	34 40	120	No. 60. "Blue head"?
61.	13 59 25	312	64	$5\frac{3}{4}$	β	...	56 10	257 11	8 56	172	No. 61. No train.
62.	14 1 44	196	33	...	...	...	58 29	140 34	36 13	...	No. 62. The object was Procyon.
								(140 51)	(37 3)		No. 63. No train.
63.	2 58	108	58	$7\frac{1}{2}$	α	...	13 59 43	53 47	11 57	225	No. 64. No train.
64.	4 49	170	50	$4\frac{1}{4}$	β	...	14 1 34	115 20	18 56	127	
65.	6 0	152	$26\frac{1}{4}$	$0\frac{1}{4}$	α, β	...	2 45	97 54	42 46	8	No. 65. "Blue head"? (At this time the meteors were much less frequent.)
66.	7 29	131	48	8	β	T	4 14	76 53	21 20	240	
67.	11 8	129	0	$10\frac{3}{4}$	β	T	7 53	78 1	69 25	322	
68.	13 25	155	53	6	β, γ	...	10 10	100 31	15 57	180	No. 68. Small train.
69.	15 15	136	40	$8\frac{1}{4}$	γ	T	12 0	82 1	29 14	248	
70.	14 16 27	157	44	...	...	...	14 13 12	102 33	24 57	...	No. 70. Regulus.
								(103 9)	(25 47)		

error of pointing, as already explained. The altitudes and azimuths of the stars were calculated by the same formulæ, and are placed in the foregoing Table, together with their altitudes and azimuths calculated from their known R. A. and N. P. D., in order to give the means of judging of the degree of accuracy to be ascribed to the observations. (The latter are put in brackets.)

I made an observation of the mean of the positions of two stationary meteors (No. 50) soon after the clouds had cleared off, and before counting from the chronometer had recommenced. The time was taken roughly by my watch, which was found by subsequent comparison to be seven minutes slower than the chronometer. The recorded time, $1^h\ 20^m$, takes into account this difference. The time of observing Regulus (No. 51) was not noted; but as this observation followed immediately after No. 50, it was conjectured from other similar cases that the interval between them was about one minute. The times for Nos. 50 and 51 are, consequently, quite uncertain; but as the place of Regulus, calculated from the observation, agrees well enough with its true place, it is not likely that they are much in error. By calculation of the R. A. and Decl. of the mean stationary point from the azimuth 83° 24′ and the altitude 25° 12′, it is found that the R. A. =150° 58′, and Decl. = +23° 36′.

Soon after seeing the stationary meteors, I noted down the mean position with reference to neighbouring stars, by mapping the stars and the estimated position on a piece of paper, from which the annexed diagram has been transferred by punctures through the paper. (It should be observed that the two meteors had about the same altitude, and the more northward one was much fainter than the other.)



By making use of the star-map in Johnston's 'Atlas of Astronomy,' I estimated the place of the meteors to be R. A.=148° 45′, and Decl.=22° 50′. The date of the map being 1850, if allowance be made for annual variations, the place for 1867·0 will be R. A.= 148° 59′, Decl.=22° 47′.

This determination I consider to be more trustworthy than the other, the R. A. of the former being probably too much in excess of that of Regulus. If double weight be given to the second determination of R. A., and equal weights be given to the declinations, the radiant point comes out R. A. =149° 39′, Decl.=+23° 12′.

Cambridge, January 3rd, 1867. J. CHALLIS.

Meteors, 1866, November 13th to 14th.

Nov. 13th, $11^h\ 28^m$.	Nov. 13th, $16^h\ 49^m$.	Nov. 13th, $14^h\ 10^m$.
h m s	h m s	s
F 3312=11 27 33·5	F 3312=16 49 41·5	Sid. T., H slow 34·26
H= 2 55 30·0	H= 8 18 30·0	Daily losing rate= 1·68
33·47	33·85	
2 56 3·47	8 19 3·85	
15 29 29·31	15 29 29·31	
11 26 34·16	16 49 34·54	
− 1 52·48	− 2 45·39	
11 24 41·68	16 46 49·15	
− 2 51·82	− 2 52·35	

Hourly rate of Chronometer= $-0^s\ 09$.

Stars for Instrumental Corrections.

	Mean time.	Observed Azimuth.	Observed Altitude.	True Azimuth.	True Altitude.	Corr. of Observed Azimuth.	Corr. of Observed Altitude.
	h m s	° ′	° ′	° ′	° ′	° ′	° ′
Procyon	..11 43 40	52 45	20 13	287 26	19 59	234 41	−0 14
Polaris	....11 45 6	304 16	53 43	178 47	53 25	234 31	−0 18
Aldebaran	..11 46 10	97 20	52 10	332 8	51 25	234 48	−0 45
Arcturus	..16 24 13	21 0	13 50	255 2	13 42	234 2	−0 8
Sirius	....16 25 6	145 45	20 0	19 48	19 14	234 3	−0 46
Aldebaran	..16 25 48	195 0	36 10	69 2	35 28	234 2	−0 42
Polaris	....16 26 48	304 0	52 12	177 47	51 55	233 47	−0 17
					Mean corrections	234 16	−0 27

Meteors, 1866, November 13th to 14th.

Observed at the Observatory at Cambridge, by Professor ADAMS.

(Error of Chronometer -2^{m} 52^{s}.)

Mean Solar Time.	True Mean Solar Time.	Observed Azimuth.	Observed Altitude.	Observed Azimuth, corrected.	Observed Altitude, corrected.	Magnitude.	Direction.	Notes.	Observer's Name.
h m s	h m s	° ′	° ′	° ′	° ′		h		
11 43 48									
52 4	11 49 12	321 0	10 0	195 16	9 33	...	9	....	G.
55 18	52 26	4 30	39 0	238 46	38 33	γ	12	....	G.
11 58 52	56 0	349 0	23 0	223 16	23 27	β	9½	....	G.
12 1 35	58 43	306 0	1 0	180 16	0 33	α	9	....	G.
2 28	11 59 36	......	......	......	......	β	10	Across β Ursæ Majoris	G.
5 47	12 2 55	297 0	18 0	171 16	17 33	β	8	....	G.
7 3	4 11	230 30	24 30	104 46	24 3	β	5	....	G.
8 36	5 44	325 0	68 30	199 16	68 3	α	9½	....	G.
9 42	6 50	247 0	23 30	121 16	23 3	γ	3	....	G.
11 18	8 26	135 0	39 0	9 16	38 33	α	4½	Train	G.
12 33	9 41	135 30	31 0	9 46	30 33	β	4	....	G.
13 32	10 40	111 30	27 0	345 46	26 33	α	4	....	G.
14 36	11 44	102 30	23 0	336 46	22 33	β	4	....	G.
18 44	15 52	54 0	25 0	289 16	24 33	α	3	Shower	G.
21 29	18 37	173 0	63 0	47 16	62 33	α	5	Fine train	G.
22 17	19 25	197 30	36 0	71 46	35 33	α	5½	Fine train	G.
24 24	21 32	100 30	27 30	334 46	27 3	α	4	....	G.
25 57	23 5	......	......	......	......	α	2½	Fine train; from Mars	G.
26 57	24 5	54 0	24 30	288 16	24 3	α	3	Fine train	G.
28 18	25 26	129 0	22 0	3 16	21 33	β	4	Train	G.
30 53	28 1	122 0	48 0	356 16	47 33	α	4	....	G.
31 45	28 53	196 30	......	70 46	......	α	...	Horizon	G.
32 42	29 50	124 0	35 0	358 16	34 33	β	4	....	G.
33 57	31 5	356 0	24 0	230 16	23 33	α	9	....	G.
34 57	32 5	......	......	......	......	α	9	ε Ursæ Majoris	G.
35 18?	32 16	......	30 0	......	......	α	8	....	G.
36 19	33 27	9 0	21 30	243 16	21 3	β	9	....	G.
37 18	34 26	10 0	16 30	244 16	16 3	α	9	....	G.
38 4	35 12	......	......	......	......	α	2	From Castor	G.
38 24	35 32	35 0	32 30	269 16	32 3	β	2	....	G.
39 24	36 32	......	......	......	......	α	...	Across Castor	G.
39 51	36 59	73 0	31 0	307 16	30 33	γ	2	....	G.
40 25	37 33	23 0	51 0	257 16	50 33	β	0½	....	G.
41 8	38 16	355 0	27 0	229 16	26 33	β	8½	....	G.

Mean Solar Time.	True Mean Solar Time.	Observed Azimuth.	Observed Altitude.	Observed Azimuth, corrected.	Observed Altitude, corrected.	Magnitude.	Direction.	Notes.	Observer's Name.
h m s	h m s	° ′	° ′	° ′	° ′		h		
12 41 41	38 49	25 0	64 0	259 16	63 33	α	12	....	G.
42 18	39 26	43 30	37 30	277 46	37 3	α	2½	....	G.
43 10	40 18	......	......	......	......	α	9½	Across ε Ursæ Majoris	G.
43 52	41 0	356 0	28 30	230 16	28 3	α	9	....	G.
44 34	41 42	313 0	21 0	187 16	20 33	α	9	....	G.
45 15	42 23	16 0	32 0	250 16	31 33	β	11	Train	G.
46 0	43 8	45 0	25 30	279 16	25 3	α	3½	....	G.
46 37	43 45	11 0	28 0	245 16	27 33	α	10	....	G.
47 30	44 38	2 30	23 0	236 46	22 33	α	...	Train	G.
48 28	45 36	353 0	40 0	227 16	39 33	α	10	....	G.
49 6	46 14	91 0	29 0	325 16	28 33	α	4	....	G.
50 22	47 30	9 0	44 30	243 16	44 3	α	10½	Clouding over	G.
51 26	48 34	......	......	......	......	α	9	δ, ε Ursæ Majoris ...	G.
52 40	49 48	36 0	41 0	270 16	40 33	α	1½	....	G.
53 16	50 24	70 0	34 30	304 16	34 3	α	2½	....	G.
53 52	51 0	85 30	22 0	319 46	21 33	β	3	....	G.
54 24	51 32	52 30	44 0	286 46	43 33	α	3	Train	G.
55 18	52 26	10 0	45 0	244 16	44 33	α	11	Train	G.
56 4	53 12	99 0	22 30	333 16	22 3	α	4	....	G.
56 45	53 53	14 0	49 0	248 16	48 33	α	11	....	G.
57 40	54 48	96 0	25 0	330 16	24 33	α	4	....	G.
12 58 48	12 55 56	46 0	22 0	280 16	21 33	α	4	No train	G.
13 33 35	13 30 43	6 0	38 30	240 16	38 3	β	5	....	G.
34 36	31 44	41 30	29 0	275 46	28 33	β	3	Flash	G.
35 18	32 26	59 0	20 0	293 16	19 33	β	4½	....	G.
35 46	32 54	22 0	27 0	256 16	26 33	γ	9	....	G.
36 8	33 16	74 0	31 0	308 16	30 33	α	3½	....	G.
37 38	34 46	59 30	27 0	293 46	26 33	α	4	....	G.
38 2	35 10	60 30	21 30	294 46	21 3	β	4½	....	G.
38 30	35 38	84 30	20 0	318 46	19 33	α	2	....	G.
38 50	35 58	61 0	36 0	295 16	35 33	β	3½	....	G.
39 15	36 23	26 30	69 0	260 46	68 33	α	11	Train	G.
39 48	36 56	70 30	51 30	304 46	51 3	α	1½	....	G.
40 27	37 35	59 0	50 0	293 16	49 33	α	2	....	G.
40 56	38 4	29 30	51 30	253 46	51 3	α	11	....	G.
41 38	38 46	67 30	76 0	301 46	75 33	α	1	....	G.
42 5	39 13	74 30	37 0	308 46	36 33	γ	3½	....	G.
42 27	39 35	33 30	53 30	267 46	53 3	α	0½	....	G.
43 29	40 37	54 30	23 0	288 46	22 33	α	3	....	G.
43 42	40 50	22 0	39 0	256 16	38 33	β	10½	....	G.
44 8	41 16	77 0	15 0	311 16	14 33	α	2	....	G.
44 48	41 56	5 30	61 0	239 46	60 33	α	10½	....	G.
45 24	42 32	73 30	28 0	307 46	27 33	β	3½	....	G.
45 57	43 5	70 0	43 0	304 16	42 33	γ	3	....	G.
46 30	43 38	39 0	20 30	273 16	20 3	β	5½	....	G.
46 55	44 3	63 0	29 0	297 16	28 33	α	6	....	G.
47 28	44 36	67 30	40 0	301 46	39 33	β	2½	....	G.
48 21	45 29	84 0	42 30	318 16	42 3	β	2½	Train	G.
49 0	46 8	56 0	28 30	290 16	28 3	α	4	Train	G.
49 29	46 37	66 0	33 30	290 16	33 3	γ	3½	....	G.
49 58	47 6	70 0	18 0	304 16	17 33	γ	4½	....	G.
50 27	47 35	74 0	38 30	308 16	38 3	γ	3	....	G.
51 16	48 24	48 0	17 30	282 16	17 3	β	4½	....	G.
52 8	49 16	96 0	28 0	320 16	27 33	α	4	Across Sirius	G.
52 52	50 0	127 0	57 0	1 16	56 33	β	3½	....	G.
54 31	51 39	164 0	66 30	38 16	66 3	α	4½	....	G.
55 10	52 18	89 0	55 0	323 16	54 33	γ	3	....	G.
55 53	53 1	151 30	62 0	25 46	61 33	α	5	....	G.
56 39	53 47	85 0	86 0	319 16	85 33	α	3	....	G.

Mean Solar Time.	True Mean Solar Time.	Observed Azimuth.	Observed Altitude.	Observed Azimuth, corrected.	Observed Altitude, corrected.	Magnitude.	Direction.	Notes.	Observer's Name.
h m s	h m s	° ′	° ′	° ′	° ′		h		
13 57 12	13 54 20	88 30	44 0	322 46	43 33	β	3½	....	G.
57 42	54 50	133 0	42 30	7 16	42 3	β	4	....	G.
58 10	55 18	93 0	31 0	327 16	30 33	γ	4½	....	G.
58 49	55 57	80 0	30 0	314 16	29 33	γ	4½	....	G.
13 59 25	56 33	72 30	42 0	306 46	41 33	γ	3	....	G.
14 0 54	58 2	20 0	25 0	254 16	24 33	α	10	....	G.
2 2	59 10	76 0	25 0	310 16	24 33	β	4	....	G.
2 37	13 59 45	105 0	21 0	339 16	20 33	β	4	....	G.
3 20	14 0 28	25 0	28 0	259 16	27 33	α	8	....	G.
4 1	1 9	26 0	38 30	260 16	38 3	β	10	....	G.
4 36	1 44	81 0	29 30	315 16	29 3	α	4	....	G.
5 25	2 33	65 0	45 0	299 16	44 33	β	2½	....	G.
6 0	3 8	42 30	42 0	276 46	41 33	α	11½	....	G.
6 48	3 56	14 30	42 0	248 46	41 33	α	9½	Train	G.
7 33	4 41	76 0	29 0	310 16	28 33	α	4½	....	G.
8 11	5 19	27 30	18 0	261 46	17 33	α	7½	....	G.
8 44	5 52	20 0	37 0	254 16	36 33	α	9½	....	G.
9 25	6 33	22 0	18 0	256 16	17 33	γ	4	....	G.
9 36	6 44	74 0	24 0	308 16	23 33	α	4½	.. ..	G.
10 44	7 52	78 0	29 0	312 16	28 33	β	4	....	G.
11 8	8 16	83 30	42 0	317 46	41 33	β	3	Across Procyon	G.
11 37	8 45	127 0	34 0	361 16	33 33	β	4	....	G.
13 10	10 18	124 30	24 0	358 46	23 33	α	4½	....	G.
13 21	10 29	81 0	46 0	315 16	45 33	α	3	....	G.
14 52	12 0	58 0	53 0	292 16	52 33	α	1½	....	G.
15 27	12 35	......	. ....	......	......	α	4	From Procyon	G.
16 52	14 0	115 0	60 0	349 16	59 33	β	4	.. ..	G.
17 44	14 52	83	......	...	......	...	...	Across Pleiades; 26°	G.
19 36	16 44	91 0	11 30	325 16	11 3	α	3	visible.	G.
20 29	17 37	110 0	39 0	344 16	38 33	α	4½	....	G.
22 26	19 34	25 0	39 0	259 16	38 33	α	9	....	G.
23 11	20 19	59 0	65 0	293 16	64 33	γ	1½	. ...	G.
23 41	20 49	101 0	29 0	335 16	28 33	β	4	... .	G.
24 30	21 38	132 0	50 0	6 16	49 33	α	4½	....	G.
25 20	22 28	121 0	37 0	355 16	36 33	α	4	....	G.
25 44	22 52	42 0	48 0	276 16	47 33	β	12	....	G.
26 50	23 58	99 0	12 0	333 16	11 33	β	4½	....	G.
31 38	28 46	102 0	23 0	336 16	22 33	β	4½	....	G.
32 9	29 17	53 0	33 30	287 16	33 3	β	5	....	G.
33 35	30 43	112 0	24 30	346 16	24 3	γ	4½	.. ..	G.
34 56	32 4	69 30	45 0	303 46	44 33	α	3½	....	G.
35 27	32 35	25 0	36 0	259 16	35 33	β	8½	....	G.
35 50	32 58	61 30	56 0	295 46	55 33	α	1½	....	G.
36 28	33 36	49 0	21 0	283 16	20 33	α	6	....	G.
37 18	34 26	5 0	16 0	239 16	15 33	β	7½	....	G.
38 4	35 12	358 30	27 0	232 46	26 33	α	8	....	G.
39 14	36 22	20 0	37 0	254 16	36 33	α	8½	Greenish colour	G.
39 49	36 57	349 30	47 0	223 46	46 33	β	8	....	G.
41 8	38 16	92 0	33 30	326 16	33 3	γ	5	....	G.
42 6	39 14	63 0	34 30	297 16	34 3	β	4½	....	G.
43 52	41 0	351 0	32 0	225 16	31 33	γ	8	....	G.
44 28	41 36	285 30	8 0	159 46	7 33	...	5	Flash	G.
46 3	43 11	72 0	65 0	306 16	64 33	γ	12	....	G.
47 19	44 27	17 0	58 0	251 16	57 33	β	10½	....	G.
48 44	45 52	104 0	35 0	338 16	34 33	β	1½	....	G.
49 38	46 46	58 30	17 0	292 46	16 33	α	5	Little more than a	G.
50 38	47 46	20 30	43 0	254 46	42 33	γ	9	flash.	G.
14 52 2	14 49 10	52 0	25 0	286 16	24 33	α	6	....	G.

Mean Solar Time.	True Mean Solar Time.	Observed Azimuth.	Observed Altitude.	Observed Azimuth, corrected.	Observed Altitude, corrected.	Magnitude.	Direction.	Notes.	Observer's Name.
h m s	h m s	° ′	° ′	° ′	° ′		h		
14 53 45	14 50 53	341 0	62 0	215 16	61 33	α	9	....	G.
54 49	51 57	335 0	59 0	209 16	58 33	α	...	....	G.
55 35	52 43	6 0	44 0	240 16	43 33	α	9	....	G.
58 40	55 48	60 0	53 0	294 16	52 33	γ	1	....	G.
14 59 32	56 40	95 0	47 0	329 16	46 33	α	3	....	G.
15 1 1	58 9	355 0	32 0	229 16	31 33	α	8	....	G.
2 32	14 59 40	308 0	68 0	172 16	67 33	α	8	....	G.
3 34	15 0 42	39 0	37 0	273 16	36 33	α	7½	Fine train	G.
4 54	1 2	......	......	......	......	α	...	To the E.	G.
4 54	1 2	......	......	......	......	α	...	To the W.	G.
6 8	3 16	60 0	37 0	294 16	36 33	β	...	....	G.
8 4	5 12	......	......	......	......	β	4	From Procyon westward.	G.
8 25	5 33	127 0	32 0	1 16	31 33	β	5		G.
9 28	6 36	14 30	25 30	248 46	25 3	α	7½	Lasted 58ˢ; green ...	G.
11 48	8 56	......	......	......	......	α	4½	....	G.
14 11	11 19	322 0	17 30	196 16	17 3	α	8	....	G.
14 54	12 2	296 0	62 30	170 16	62 3	α	7½	....	G.
15 47	12 55	349 0	64 30	223 16	64 3	α	9	....	G.
16 40	13 48	15 0	33 30	249 16	33 3	β	7½	....	G.
17 16	14 24	1 0	31 30	235 16	31 3	β	7½	....	G.
18 15	15 23	291 30	37 0	165 46	36 33	β	7½	....	G.
19 15	16 23	262 0	24 0	136 16	23 33	α	7½	....	G.
20 59	18 7	300 0	28 0	174 16	27 33	β	7½	....	G.
21 34	18 42	337 30	42 0	211 46	41 33	α	8	....	G.
22 28	19 36	0 0	38 30	234 16	38 3	γ	5	....	G.
25 0	22 8	141 0	23 0	15 16	22 33	α	4½	....	G.
25 11	22 19	12 30	34 0	246 46	33 33	β	7½	....	G.
26 13	23 21	354 0	21 0	228 16	20 33	β	7½	....	G.
27 13	24 21	17 0	36 0	251 16	35 33	α	7½	....	G.
28 14	25 22	332 0	56 0	206 16	55 33	α	7½	....	G.
28 23	25 31	261 0	63 0	135 16	62 33	α	6½	....	G.
29 2	26 10	331 0	40 30	205 16	40 3	..	8	Train	G.
31 29	28 37	3 30	55 30	237 46	55 3	α	8	....	G.
33 19	30 27	62 0	66 0	296 16	65 33	α	11	....	G.
34 10	31 18	324 30	42 30	198 46	42 3	α	7½	....	G.
37 7	34 15	339 0	24 0	213 16	23 33	γ	7½	....	G.
37 45	34 53	59 30	72 0	293 46	71 33	α	11	Lasted several secs...	G.
38 2	35 10	64 30	27 30	298 46	27 3	α	5	....	G
39 42	36 50	46 0	25 0	280 16	24 33	γ	7	....	G.
40 26	37 34	93 0	20 0	327 16	19 33	α	4½	....	G.
40 38	37 46	......	......	......	......	...	...	Ran across Leo in a curved direction.	G.
41 36	38 44	67 30	49 30	301 46	49 3	α	1½		G.
43 44	40 52	359 30	23 0	233 46	22 33	α	7½	Fine train	G.
44 40	41 48	16 0	21 0	250 16	20 33	β	7	....	G.
45 33	42 41	326 30	39 0	200 46	38 33	γ	8	....	G.
46 24	43 32	293 0	23 0	267 16	22 33	α	7½	Flash	G.
47 4	44 12	352 0	37 0	226 16	36 33	β	7½	....	G.
49 27	46 35	295 30	18 30	269 46	18 3	α	7	Train visible for 50ˢ..	G.
51 19	48 27	322 0	53 0	196 16	52 33	β	8	....	G.
53 28	50 36	5 0	26 30	239 16	26 3	β	7½	....	G.
55 30	52 38	4 30	14 0	238 46	13 33	α	7½	....	G.
15 58 18	55 26	42 0	53 0	276 16	52 33	α	10	....	G.
16 0 12	15 57 20	25 0	34 0	259 16	33 33	β	7½	....	G.
2 21	15 59 29	9 0	54 0	243 16	53 33	β	8	....	G.
3 56	16 1 4	331 30	41 30	205 46	41 3	α	7½	....	G.
4 31	1 39	331 30	28 30	205 46	28 3	α	7½	....	G.
5 26	2 34	298 30	6 30	172 46	6 3	α	...	Flash	G.
16 7 17	16 4 25	......	......	......	......	α	10	Between α, β Ursæ.	G.

Mean Solar Time.	True Mean Solar Time.	Observed Azimuth.	Observed Altitude.	Observed Azimuth, corrected.	Observed Altitude, corrected.	Magnitude.	Direction.	Notes.	Observer's Name.
16 8 48	16 5 56	223 30	28 0	97 46	27 33	α	5½	....	G.
9 4	6 12	290 0	31 30	164 16	31 3	α	7½	....	G.
11 29	8 37	22 0	60 0	256 16	59 33	α	9	....	G.
12 48	9 56	74 0	59 0	308 16	58 33	α	11	....	G.
14 29	11 37	69 0	30 0	303 16	29 33	α	4½	....	G.
15 2	12 10	116 0	48 30	350 16	48 3	α	4½	....	G.
16 8	13 16	67 30	53 0	301 46	52 33	α	10½	....	G.
16 53	14 1	29 0	61 0	263 16	60 33	α	9	....	G.
20 3	17 11	351 0	14 30	225 16	14 3	α	7½	....	G.
20 47	17 55	327 0	21 30	201 16	21 3	γ	7	....	G.
22 22	19 30	231 0	57 0	105 16	56 33	α	7	....	G.
30 4	27 12	214 0	56 0	88 16	55 33	α	5½	....	G.
31 18	28 26	51 0	31 0	285 16	30 3	γ	7	....	G.
32 1	29 9	12 0	40 30	246 16	40 3	α	7½	....	G.
34 33	31 41	341 30	65 0	215 46	64 33	α	8	....	G.
38 47	35 55	23 0	36 0	257 16	35 33	γ	7½	....	G.
39 52	37 0	322 0	59 30	196 16	59 3	γ	7½	....	G.
42 6	39 14	43 0	65 0	277 16	64 33	β	9	....	G.
16 44 46	16 41 54	56 0	81 0	290 16	80 33	γ	11	....	G.
			Number of meteors observed, 229.						
11 46 32	11 43 40	20 13	52 45	254 16	52 18	..	...	Procyon	A.
11 59 56	57 4	43 30	51 0	277 46	50 33	α	2	....	A.
12 1 35	11 58 43	5 0	42 0	239 16	41 33	α	2	Train	A.
4 37	12 1 45	46 0	15 30	270 16	15 3	γ	3	....	A.
6 13	3 21	48 0	22 0	282 16	21 33	γ	3	....	A.
9 44	6 52	47 0	21 30	281 16	21 3	α	3¾	Train	A.
12 41	9 49	34 30	13 0	268 46	12 33	α	4	....	A.
13 0	10 8	28 0	16 0	262 16	15 33	α	3¼	....	A.
14 30	11 38	51 0	30 30	285 16	30 3	β	2¾	....	A.
15 35	12 43	21 30	34 30	255 46	34 3	α	1½	....	A.
16 37	13 45	42 0	25 30	276 16	25 3	β	3	....	A.
17 37	14 45	46 0	25 30	280 16	25 3	γ	3	....	A.
18 2	15 10	55 0	23 0	289 16	22 33	α	3¼	....	A.
18 33	15 41	54 0	24 30	288 16	24 3	α	3	....	A.
19 59	17 7	41 30	19 0	275 46	18 33	α	3½	....	A.
26 15	23 23	3 0	43 0	237 16	42 33	α	11	Train	A.
27 36	24 44	46 0	21 30	280 16	21 3	β	3	....	A.
28 26	25 34	......	......	......	......	α	3½	α Orionis..............	A.
29 51	26 59	83 0	48 30	317 16	48 3	α	2¾	....	A.
30 44	27 52	90 0	45 0	224 16	44 33	α	3	....	A.
31 16	28 24	39 0	25 0	273 16	24 33	β	3	....	A.
32 38	29 46	7 0	25 0	241 16	24 33	α	10	....	A.
33 29	30 37	52 0	26 30	286 16	26 3	α	3½	....	A.
34 5	31 13	21 0	34 0	255 16	33 33	α	12	....	A.
34 57	32 5	......	......	......	......	α	9	ϵ Ursæ Majoris	A.
36 34	33 42	134 0	28 30	8 16	28 3	α	4½	....	A.
46 42	43 50	215 0	57 30	89 16	57 3	α	6	....	A.
48 25	45 33	209 30	52 0	73 46	51 33	α	6¼	....	A.
49 48	46 56	......	......	.....	......	α	4	Across the Nebulæ in	A.
50 1	47 9	132 0	15 30	6 16	15 3	α	4	Orion.	A.
51 5	48 13	74 0	27 30	238 16	27 3	α	4	....	A.
54 29	51 37	104 0	26 30	338 16	26 3	α	4	....	A.
56 45	53 53	62 30	34 0	296 46	33 33	α	3	....	A.
57 24	54 32	32 0	43 0	266 16	42 33	β	1	....	A.
12 58 18	55 26	57 0	29 0	291 16	28 33	α	3½	....	A.
13 1 55	12 59 3	133 0	18 0	7 16	17 33	...	2½	Flash; began to rain	A.
14 47 1	14 44 9	......	......	......	......	α	4½	Across mid.* in Orion	A.

Mean Solar Time.	True Mean Solar Time.	Observed Azimuth.	Observed Altitude.	Observed Azimuth, corrected.	Observed Altitude, corrected.	Magnitude.	Direction.	Notes.	Observer's Name.
h m s	h m s	° ′	° ′	° ′	° ′		h		
54 0	51 8	......	......	......	......	α	4	A little above γ	A.
55 10	52 18	......	......	......	......	...	4¾	Orionis.	A.
14 56 9	53 17	......	......	.....	......	...	...	¼-way Mars to Pol-	A.
15 1 1	14 58 9	355 0	32 0	229 16	31 33	α	8	lux.	A.
11 48	15 8 56	......	......	......	......	α	4½	Nearly across little	A.
12 31	9 39	169 0	24 30	43 16	24 3	α	4½	star above β Orion.	A.
19 54	17 2	112 0	20 0	336 16	19 3	β	7½	....	A.
21 18	18 26	99 30	31 30	333 46	31 3	β	4½	....	A.
25 13	22 21	205 30	45 30	79 46	45 3	α	5	....	A.
28 23	25 31	261 0	63 0	135 16	62 33	α	6½	....	A.
30 5	27 13	347 30	22 0	221 46	21 33	α	7½	....	A.
32 41	29 49	151 0	20 0	25 16	19 33	α	4¼	....	A.
35 49	32 57	124 0	36 30	358 16	36 3	α	4½	....	A.
40 1	37 9	27 0	25 0	261 16	24 33	α	7½	....	A.
41 51	38 59	4 0	62 0	238 16	61 33	α	10	....	A.
51 48	48 56	155 0	34 0	29 16	33 33	α	4½	....	A.
52 43	49 51	129 30	49 30	3 46	49 3	α	4¼	....	A.
53 46	50 54	192 0	32 30	66 16	32 3	β	5	....	A.
54 37	51 45	170 0	25 0	44 16	24 33	β	5	....	A.
56 5	53 13	210 0	31 0	84 16	30 33	α	5	....	A.
15 57 10	15 54 18	64 0	27 30	298 16	27 3	β	6½	....	A.
16 2 53	16 0 1	......	...	......	....	α	..	Across the four stars	A.
8 48	5 56	223 30	28 0	97 46	27 33	α	5½	in Great Bear.	A.
22 25	19 33	253 30	19 0	127 46	18 33	α	6	....	A.
23 20	20 28	260 0	27 0	134 16	26 33	α	6	....	A.
16 25 52	16 23 0	268 0	65 0	142 16	64 33	α	5¾	....	A.

Number of meteors observed, 63.——Total number 292.

I. Meteors doubly observed.

(1) 1866, November 13th, 11^h 22^m P.M. (Haddenham).

At an early stage of the great November shower, when bright meteors were yet uncommon, a meteor nearly as bright as Venus was recorded by Mr. Dawes at Haddenham, in Bucks; and almost simultaneously with it a meteor of unusual brilliancy was seen by Mr. T. Crumplen at Primrose Hill in London (see Catalogue). The descriptions of its appearance at the two places are essentially the same, and evidently refer to the same meteor. The parallax of these observations is 12°, and the height of the meteor, assuming a distance of thirty-six miles between the stations, is just sixty miles above the surface of the earth.

(2) 1866, November 14th, 12^h 40^m 45^s A.M. (Glasgow).

The meteor passed nearly over St. Andrews, in Scotland, where it appeared to consist of three parts, each equal to Venus. A part of the streak remained visible as an oval light-cloud for eight minutes before it disappeared (see Catalogue). This portion of the streak was seen at an altitude of 40° above the horizon at Glasgow, in the direction of St. Andrews. At St. Andrews it disappeared at an angle of 15° from the zenith, nearly towards Glasgow. The distance between the two stations is nearly sixty-five miles, and the parallax of about 60° corresponds to a height of not quite fifty miles above the surface of the earth.

(3) 1866, November 14th, 1^h 8^m A.M. (Cardiff).

The apparent position of the meteor at the beginning and end of its visible path, as referred to the stars by Messrs. A. and J. Thomson at Cardiff, and Mr. H. S. Heinecken at Sidmouth, are in the most perfect geometrical accordance with the respective geographical positions of the two stations from one another. As the stations are respectively north and south from one another, and the meteor passed between them from east to west, the real altitude of the meteor, and the extent of the luminous streak which it left floating upon its path for at least ten minutes before it disappeared, can be determined with exactness. The direct distance of Sidmouth from Cardiff is just fifty British statute miles. The parallax of the meteor at its first appearance was 20°, and corresponds to a height of 100 miles above Petersfield, in Hampshire (lat. 51° N., long. 0° 55′ W. from Greenwich). The meteor disappeared between the two stations, and its parallax was then 50°. Its real altitude at the instant of its disappearance was fifty-three miles above Tiverton, in Devonshire (lat. 50° 55′ N., long. 3° 39′ W. from Greenwich), which point it reached after an aërial flight of 120 miles directed exactly from the radiant-point (near x Leonis) of the November meteoric shower, in the centre of Leo's "Sickle."

At the final distance of the meteor from Cardiff, sixteen or eighteen miles would subtend 15°, which was the length (see Catalogue) of that portion of the luminous streak which collected itself into a cloud after the nucleus had disappeared. A "few minutes of arc" (see Catalogue) would correspond to as many hundred feet at the same distance; this was accordingly the width of the straight portion of the luminous streak, while the oval light-cloud, which remained visible ten minutes, if it subtended the apparent width of only two diameters of the moon, must have measured at least one mile in thickness.

(4) 1866, November 14th, 2^h 12^m 30^s A.M. (Hawkhurst).

The apparent position of the meteor, seen at this time to leave a very persistent streak at Hawkhurst, is not compatible with the apparent place of a very similar meteor observed at very nearly the same moment by Mr. Lowe at Nottingham, so as to make it possible to compute their distance as if the meteors were identical. But it is probable that two meteors, nearly simultaneous in time, were seen at the two stations in nearly the same quarter of the heavens.

(5) 1866, November 14th, 2^h 14^m A.M. (Glasgow).

An observation of the meteor seen at Glasgow was also recorded by Mr. G. Forbes at St. Andrews. It moved, however, with reference to the two stations, so nearly in a plane containing the base-line drawn between them, that although a considerable parallax of the kind attributable to their very wide displacement is perfectly apparent, additional observations at other places are required to define its real altitude.

(6) 1866, November 14th, 2^h 40^m 58^s (Aberdeen).

A brilliant fireball of the November shower was seen over the whole of Scotland and as far south as Nottingham, in England. Observations of its apparent place were recorded at Sunderland in England, and at Glasgow, Edinburgh, and Aberdeen in Scotland (see next page). A comparison of these accounts assigns to the light-cloud left by the meteor near the termination of its course an altitude of between sixty-one and sixty-seven miles above the

earth's surface in the neighburhood of Dundee. (Proceedings of the Glasgow Philosophical Society, vol. vi. p. 207.)

(7) 1867, August 9th, 11^h 46^m P.M. (London and Birmingham).

Two bright meteors of the August shower, in almost exactly the same quarter of the sky, were recorded simultaneously at Birmingham and London at this hour (see Catalogue). The resemblance between the two meteors is, however, casual; for the lines of sight, instead of converging towards each other very rapidly, as might be expected to take place from the great distance between the stations if a single meteor were under consideration, actually diverge from each other to an extent of 5° or 6°, and evidently point to two different meteors appearing almost simultaneously in time and in the same quarter of the sky at either place.

(8) 1867, August 10th, 10^h 57^m P.M. (Birmingham and London).

The two bright meteors simultaneously recorded at this time by strict observations at Birmingham and London, during a period of positive scarcity of shooting-stars, correspond exactly in their apparent place of disappearance with the supposition of a large displacement by parallax (of about 45°) in the direction of a straight line joining Birmingham and London. The identity of the two meteors must accordingly be regarded as perfectly confirmed, although the partial view obtained at London permits only the end point, or point of disappearance, to be fixed. This was at a height of seventy-six miles above the earth's surface in the neighbourhood of Bristol.

II. Large Meteors.

(1) 1862, April 25th, 8^h 20^m P.M. (local time), Hobart Town, Van Diemen's Land.

The following account of a large meteor seen in the southern hemisphere appears in the 'Results of twenty-five years' Meteorological Observations for Hobart Town,' by F. Abbot, F.R.A.S., p. 17. Although appearing in the southern sky, the meteor belongs to a date when fine meteors are not uncommonly seen in considerable numbers in the northern hemisphere; and it is frequently the case that meteoric displays are visible at the same time in both the north and south hemispheres of the globe.

"On the 25th of April 1862, while observing the accompanying cluster κ Crux at 8^h 20^m P.M., a remarkably fine meteor crossed the zenith from ν in the constellation of Centaurus, to Nebula Major. By estimation the meteor was about 15′ in diameter, traversing about 60° in four seconds of time, leaving a long and remarkable train of sparks that continued, from first to last, about ten minutes, which gradually contracted into an oblong form from 1° to 2° in diameter, and for a time appeared to station itself a little to the west of γ Crux. During the time of transit the meteor gave a brilliant illumination, much more incandescent than that produced by the full moon."

(2) 1866, November 14th, 12^h 52^m 30^s A.M., G. M. T (Aberdeen)*.

"Being in the observatory for a few minutes, I was called by Professor Thomson; thinking it simply an expression of delight, I paid no attention to it, except to note the time. I was twice called again, and running out, was

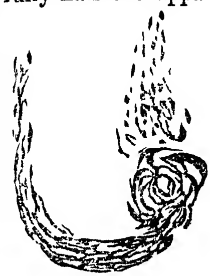
* This and the two following descriptions of large meteors are contained in a Report on the Meteors of the 13th–14th of November, 1866, to Professor Grant, of the Glasgow Observatory, by Mr. D. Gill, Assistant at the Observatory, King's College, Aberdeen.

just in time to see a glare of light which suddenly disappeared, leaving a luminous patch in the east.

"Professor Thomson describes it as a brilliant meteor of half the apparent diameter of the moon, of an intense white light, which rose due east of our observatory, apparently from the sea, slowly describing a small semicircle of 3° diameter from S. to N., occupying nearly thirty seconds in doing so, and leaving behind it a faint luminous track, which soon disappeared.

(3) Ibid. $1^{h}\ 11^{m}\ 33^{s}$ A.M.

"My attention at this instant was attracted by a glare of light in the east. This proceeded from a brilliant ball of a reddish colour, fully half the apparent diameter of the moon, which seemed to be rising from the sea directly under the star ϵ Virginis. After attaining an altitude of 8° or 10°, it seemed to arch over towards the north, describing a semi-circle of about 2° radius; when the lower half of the meteor seemed to shell off, emitting a train of luminous sparks which fell vertically downwards, completing the arch formed by the slightly luminous train of the meteor. The accompanying rough sketch is a copy of one made in my notebook at the time, and represents the meteor when it first burst. The total time of visibility of the meteor may have been about ten seconds.



(4) Ibid. $2^{h}\ 40^{m}\ 58^{s}$ A.M.

"On my way home, when about half a mile due south of the observatory, my attention was attracted at this instant by a glare of light. Looking up, I feared that I had missed some brilliant meteor, when presently, beyond a housetop close to the east of me, appeared a most billiant meteor moving nearly horizontally with an apparently slow and diminishing motion. I ran to the middle of the street, which enabled me to see backwards (eastwards) along its path (indicated by its train), which appeared to have commenced somewhere between Mars and Pollux, rather nearer the latter. The nucleus passed over α Tauri, rested an instant over the little pair of stars in the V, and disappeared without noise. The path and point of disappearance can be represented thus (fig. 1).

Fig. 1.

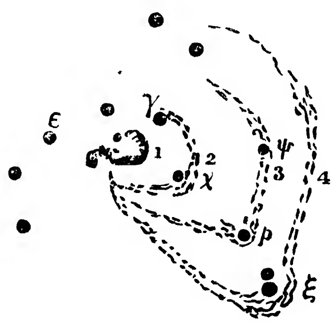
"I should estimate the apparent diameter of this meteor as one-fifth that of the moon. But the intensity of its light was incomparably greater than that of any previously observed, and its character more resembled sunlight than any other.

"The most remarkable feature of this meteor, however, was the train. This was of a pale-yellow colour, and at first it remained as a band of dense nebulous-looking light, about half a diameter of the moon in breadth, along the path of the meteor, as in No. 1.

"After two minutes the train wound about, and assumed the appearance of No. 2.

"After $3\frac{1}{2}$ minutes it had collected itself into a nebulous-looking cloud, as in No. 3, which remained vividly distinct until four minutes (by the watch) after the appearance of the meteor, when it was obscured by a cloud."

Professor Grant's notes of its appearance at Glasgow refer principally to the luminous streak, of which a drawing at the time, by Mr. Herschel, is here appended in illustration of Professor Grant's description.



"At 14^h 41^m, G. M. T., my attention was directed to an extraordinary blaze of light in the constellation Ursa Major. When first seen it presented the appearance of a slightly curved broad band of light, indicative of the train of a meteor which itself had already disappeared, and which, judging from what was left behind, must have far exceeded in lustre any of the meteors seen during the night. The first apparition of this remarkable phenomenon I unfortunately lost, having been engaged at the time in writing down some details in my notebook. It was obvious, however, that the meteor had only just vanished, for the residuary mass of light was still very bright. I could only compare its appearance in this respect to that presented in a dark night by the blazing furnace of one of the great iron-works in the neighbourhood of Glasgow. In less than a minute after it was first seen it assumed the appearance of a horseshoe, or inverted arch, of diffused and rapidly diminishing light, one extremity of which was projected upon ϵ Ursæ Majoris, and the other upon γ and δ of the same constellation [No. 1]. Gradually it expanded in dimensions and grew fainter; at the same time the arch became more elongated and pointed, suggesting its resemblance to a merry-thought, or the outline of a heart. At 14^h 48^m the western extremity was still attached to ϵ Ursæ Majoris, but the eastern had drifted from γ and δ to α and β of the same constellation [No. 3]; an effect doubtless attributable to the prevalence of a westerly wind, which was blowing at the time. The apex was seen to descend as far as ψ Ursæ Majoris, or perhaps a little lower. This remarkable object continued to be distinctly visible till 14^h 56^m; even at 15^h traces of it might still be discerned"*.

Professor Piazzi Smyth thus describes the appearance of the train at the Carlton Hill Observatory at Edinburgh:—

* Explanation of the figure.—No. 1. Appearance of the streak at 14^h 42^m, G. M. T. No. 2. Appearance at 14^h 44^m. No. 3. Appearance at 14^h 48^m. No. 4. Shortly before disappearance at 14^h 52^m.

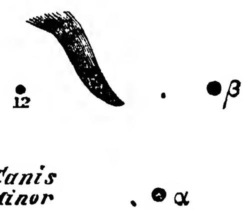
"Of bright meteors . . . there must have been one about $2^h\ 40^m$ A.M., between α Ursæ Majoris and α Ursæ Minoris; for immediately thereafter the central part of its luminous track was brilliantly conspicuous, like a silver snake in the sky. From minute to minute the luminous line became more corrugated, widening and becoming fainter by degrees; and also drifting, apparently under the action of the north-west wind blowing at the time; even after a quarter of an hour the train-matter was still visible, but changed to something like the outline of a gigantic pear, and drifted some 30° from its first position."

At Sunderland, in Durham, Mr. Backhouse obtained a view of the persistent light-streak, and to his report is added a description of another meteor, and drawings of their appearance.

"At $2^h\ 21^m$, a meteor as bright as Jupiter, directed from ζ Leonis, left a train, a part of which lasted two minutes. At $2^h\ 22^m\ 30^s$ it was like fig. 1.

"On looking out of the window at $2^h\ 42^m$ A.M. I discerned the train of a meteor, the upper part being a patch of light much brighter than the rest.

Fig. 1.



"Fig. 2 shows it soon after I discovered it, and fig. 3 at $2^h\ 44^m\ 40^s$ A.M. It was visible at $2^h\ 53^m$.

Fig. 2.

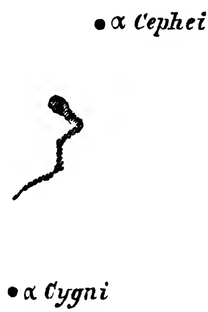
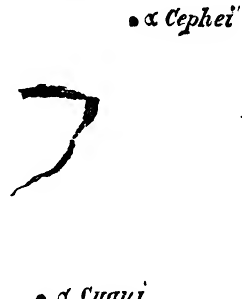


Fig. 3.



"I did not see the meteor, but am told that it was as bright as the moon."

A description of the meteor, as seen at Newcastle-upon-Tyne by Mr. T. P. Barkas, gives a perfectly similar account of its appearance. The meteor shot past Polaris, and became extinguished in the neighbourhood of β Cephei.

(4) 1866, November 20th, 4^h A.M. (local time), Nashville, Tenn. U.S.A. Extract from the New York 'World,' 24th November.

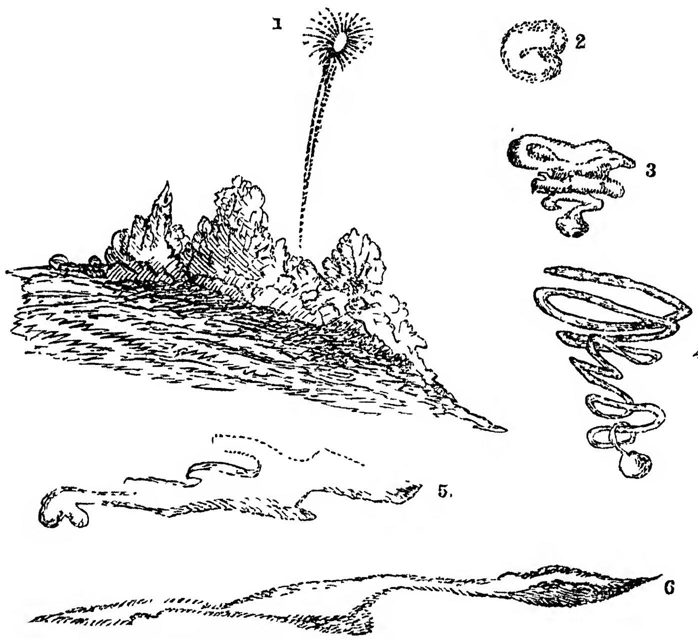
"*Meteorological Phenomenon.*—At Nashville, about four o'clock last Tuesday morning [the 20th of November 1866], a meteor lighting the whole heavens was seen in the direction of Rome, Ga., moving rapidly south-west. It appeared like a ball of fire as large as the sun. It exploded apparently ten miles off with a tremendous report, like a 40-lb. cannon, that shook the earth and made the windows rattle."

The "phenomenon," if it actually took place as here described, forms an addition to the list of detonating meteors happening about the 20th of November, already enumerated in previous Reports (British Association Report, 1866, p. 125).

(5) 1867, June 11th, 8^h P.M., G.M.T. (France and Switzerland).

Accounts of this meteor were collected by Professor Ed. Hagenbach-Bischoff at Basle, and by M. W. de Fonvielle at Paris. The following description of its appearance, first ascending vertically and then slightly falling, at Basle shows that a projection of its course prolonged, would pass nearly through that town.

"*Basle,* June 13th, 1867.—I stood with a telescope on the 'Bruderholz,' near my house at Madörg, when the meteor made its appearance. As soon



Fireball of June 11th, 1867; and appearance of the streak, as observed in the telescope, at Basle, by H. Christ.

as it appeared, directly over the middle of the forest, I pointed the telescope to it and examined therewith the successive changes of the white, semitransparent, faintly luminous cloud which it left for the space of about an hour.

"Immediately after the disappearance of the nucleus (which rested like a fixed star at the summit of its course for about half a second, fig. 1) there remained at the spot a small globular cloud (fig. 2) which rapidly extended itself, as if dissipated by an upward current of air, as in fig. 3.

"It then took the form of a winding, riband-like, or irregularly spiral curve (fig. 4), which it preserved for the space of about half an hour, and at last gradually assumed the cirrus-forms shown in figs. 5 and 6, and disappeared in the approaching darkness after nine o'clock. The accompanying figures are exact and careful representations of its successive transformations. One remarkable feature of the phenomenon was that the originally deposited small globular cloud of vapour remained visible for a long time, as shown in figs. 3 and 4, at the basis of the streak." (Report of H. Christ to Professor E. Hagenbach-Bischoff.)

Excellent bearings of the meteor taken in the neighbourdood of Basle en-

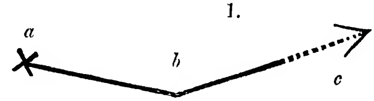
able Professor Hagenbach to fix the summit of its apparent path at that place at $12\frac{1}{2}°$ above the horizon, 45° west from north, in the direction of Dunkirk, Oise, Aisne, Meuse, and Marne in the North of France.

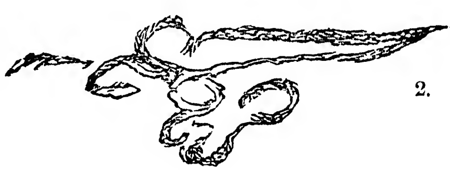
The meteor was seen in daylight at Paris proceeding almost horizontally at an altitude of about $22\frac{1}{2}°$, from 3° west to 34° east of north (Comptes Rendus, 24th June, 1867)*. Comparing together the observations at Basle and Paris, Professor Hagenbach concludes that the meteor moved from over Dunkirk to over the neighbourhood of Cambray, in the Département du Nord, at a height of between sixty-five and eighty-five miles above the earth in a direction from north-west towards south-east.

The following observation at St. Quentin, in Aisne, twenty-five miles south of Cambray, shows that the meteor continued its course still further towards the east, and probably passed a short distance south of St. Quentin; and of the course assigned to it by Professor Hagenbach.

"A very small point of crimson-red light was first seen, appearing in the east and proceeding rapidly northwards, as from *a* to *b* in the figure (No. 1). It then changed its appearance to a flame-colour, and suddenly altered its direction at an obtuse angle descending towards the west of north, as from *b* to *c*, and gradually became extinguished. Its duration was about two seconds. After its disappearance there remained in the sky, traced with wonderful distinctness, a bright white streak in the form of fig. 2. In the course of ten minutes its lines grew wider and became diffuse." (Report of Hormisdas Leblanc, Mayor of St. Quentin, to M. W. de Fonvielle.)

1.





2.

The sudden change of course, noticed by M. Leblanc, was probably attended by a detonation; for at Braine sur Viste, near Soisson, in Aisne, about thirty miles south of St Quentin, M. Ed. Lainney reports to M. de Fonvielle :—

"Walking in the fields at about eight o'clock on the evening of the 11th of June, we heard a heavy report like that of a distant mine exploding, or of a battery of cannon fired off in the distance. Twenty miles from this place, at Fresnes, a luminous meteor was seen moving from N.W. to S.E., and it burst with a loud explosion."

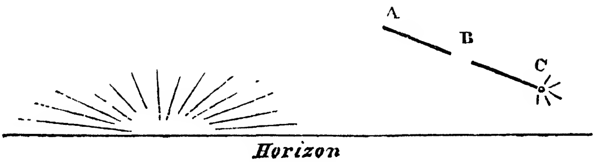
Distant views of the meteor were obtained in the Côte d'Or and in Haute Marne, which confirm the other accounts of the long duration of the smoke-like train, and afford some more details of the position of the meteor. The first of these reports is by M. L. Roussy, chronometer-maker to the Toulouse Observatory, whose acquaintance with the writings of M. Petit on the subject of luminous meteors led him to observe the phenomenon with particular attention.

"I was in the train which had just left the station near Dijon (Côte d'Or) returning to Paris, and leaning against the window on the right of the train, when at $8^h\ 9^m$ (Paris time) I perceived a luminous streak of very intense light preceded by an advancing fireball, of which the accompanying figure

* M. J. J. Silbermann, who saw the meteor from the Collége de France, thought that its altitude was "about 60°" (Letter to M. de Fonvielle); and other accounts at Paris assign intermediate heights to these.

(fig. 1) is a rough sketch. A break in the streak about the middle of its

Fig. 1.

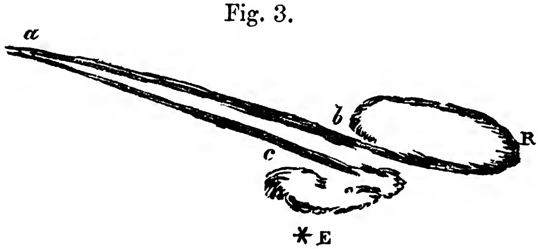


length showed a point where the fireball, on arriving from A to B, must have undergone a partial extinction for an instant before acquiring again the splendour with which I saw it in its course from B to C. At the latter point it disappeared, as shown in the figure, with a shower of sparks at about 31° or 32° above the horizon.

"During the space of eight minutes the train of light preserved its form, while its brilliancy at the same time gradually decreased. It then grew more diffuse, both lengthening and widening, and undergoing a deformation of its shape at the ends, which folded in upon themselves thus—(see fig. 2). It still continued to increase in length and volume, and to move pretty rapidly towards the west, while the changes of its shape continued. At nine o'clock it was still visible with its original brightness, and having now the shape shown in fig. 3, which it preserved

Fig. 2.

Fig. 3.



until it vanished. Its colour at this time resembled that of steam from the funnel of a locomotive engine discoloured by coal-smoke. The point *a* formed the apex of a triangle where two lines of the streak *a b*, *a c* met together without any portion of the streak between them. At $9^h\ 5^m$ P.M. a star (E) a little over, and to the right of the sunset made its appearance, and by its aid the gradual motion of the streak towards the west was easily perceived.

"I expected that from the great height at which the streak was probably placed, it would still continue to be illuminated for a much longer time, but it gradually disappeared at the same time that the stars began to make their appearance in the sky.

"At $9^h\ 15^m$ P.M. the length from *a* to R was three times the length which the streak had when it was first deposited."

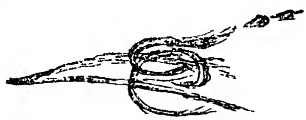
At Vignes (Haute Marne) the meteor appeared in the north-west and moved slowly and nearly horizontally at a small apparent height above the horizon from north-west to south-east. It was brilliant white, and disappeared in ten or twelve seconds without explosion, leaving a white streak of light, which at first had the appearance represented in fig. 1, which it pre-

served for some minutes. The streak then expanded, and became bent and

Fig. 1.

Fig. 2.

Fig. 3.



twisted without losing its bright and dense appearance into the form of fig. 2. Ten or twelve minutes after its first appearance its form was that of fig. 3. It was now drifting slowly from the east towards the west, and without losing anything of its sharpness of definition and bright white appearance it was hidden behind a cloud, fifteen or twenty minutes after the time of its first appearance. (Report of M. Gilbin to M. de Fonvielle.)

The accounts of numerous other observers in Paris, Rheims, and Strasbourg, in France, at Luxembourg, and at Geneva, Bern, Zürich, and Lielthal, in Switzerland, as well as at Lindau on the eastern shore of the Lake of Constance, testify to the same general appearance of the meteor, the occurrence of which near the date of the 9th of June, marked in the present year by the fall of an aërolite (noticed in the next paragraph) in Algeria, and in 1866 by the stonefall of Knyahinya, appears to connect it with the same aërolitic period to which the latter meteorites belong.

III. Aërolites.

1867, June 9th, $10^h\ 30^m$ P.M. (local time). Plain of Tadjera, Amer Guebala, near Setif, Algeria.

A luminous body was seen to descend towards the earth, and when arrived at a certain height to burst into fragments. The flash of light was followed by rumbling noises, which ended in three loud reports, and were attended by a fall of aërolites. Three stones, which are undoubted meteorites, were afterwards picked up, and brought to Setif, which is ten miles from the place of fall. A fragment, which is deposited in the museum at Algiers, is placed at the disposal of the French Academy. (Comptes Rendus, August 5th, 1867.)

IV. Shower-Meteors.

Meteoric shower of October 18th to 20th, 1866.

In these Reports for the year 1847, the following observation occurs, which refers to an abundance of meteors about the date of the 17th to the 26th of October, seen at Whitehaven by Mr. J. F. Miller, in the previous year:—

"I never saw more meteors than this winter. From October 17th to December 17th they appeared in great numbers every clear night, some as large as Jupiter. The most remarkable were between October 17th and 26th, and on November 10th, 11th, and 12th."

The occurrence of a meteoric shower with a very precise and well-defined radiant-point at ν Orionis on the 18th of October 1864 and 20th of October 1865, was noticed in these Reports (for 1865, p. 122; and 1866, p. 134), and the remarkable peculiarity of meteors emanating from this radiant-point was pointed out, that they are characterized by very ruddy colour, and by leaving voluminous streaks.

On the nights of the 18th–20th of October 1866, the sky was so generally overcast in England that no special observations of the recurrence of the shower could be collected. An incidental confirmation of the periodical recurrence of remarkably fine meteors on this date is, however, afforded in the present catalogue by the account of an unusually large meteor, seen at sea between England and Ireland, on the morning of the 19th of October 1866; and described by Mr. J. Seymour Davies. The fireball presented precisely those peculiar features which characterize the meteors emanating from this special radiant-point, both by its violet colour, approaching to crimson, and by leaving a persistent luminous streak, which remained visible five minutes by the watch. The direction of the meteor, "from south to north," also agrees with that which meteors passing nearly overhead from this radiant-point would pursue at 3^h A.M. (which was the hour of the observation), when the constellation of Orion, in which the radiant-point is placed, is situated upon the southern meridian.

Meteor-shower of November 13th–14th, 1866.

On the night of the 12th–13th of November the densely overcast state of the sky in England permitted few observations to be recorded.

At the Observatory, King's College, Aberdeen, five observers took their station at 10^h P.M., and watched until $1^h\ 30^m$ A.M. on the 13th. Mr. D. Gill reports:—

"The sky was beautifully clear, excepting a low bank of cloud, which extended all round the horizon. At $12^h\ 50^m$ small patches of cloud appeared in different parts of the sky, but entirely disappeared by $1^h\ 30^m$ A.M. Streaks of aurora appeared irregularly throughout the whole night.

"Comparatively few meteors with trains were observed on this evening and the following morning, most of the phenomena partaking more of the appearance of ordinary shooting-stars. In the accompanying journal their general position only is noted."

The particulars of a few meteors of a marked description are entered above, in the Catalogue. The numbers of the meteors seen in the successive half hours by the five observers were as follows:—

	h m	h m	h m	h m	h m	h m	m h
In the half-hour ending	10 30	11 0	11 30	12 0	12 30	1 0	1 30
Number of meteors seen	4	2	12	12	7	8	7

Two flashes of lightning, in the S.S.E., were seen at $1^h\ 1^m$ and $1^h\ 6^m\ 43^s$ A.M.

At Glasgow, with the sky two-thirds clear, Mr. A. S. Herschel recorded two meteors in twenty minutes on the same morning, from 3^h to $3^h\ 20^m$ A.M.

November 13th–14th.—Clouds generally prevailed on the evening of the 13th, and cleared off on the morning of the 14th of November. The following are extracts from the principal reports on the apparition of the shower:—

At *Manchester*.—"The night was tempestuous, with lightning, rain, and hail until $12^h\ 15^m$ A.M. on the 14th, after which the sky frequently became partially, or even totally obscured at intervals, but remained tolerably clear

until $1^h\ 30^m$ A.M. The finest part of the display endured from $12^h\ 45^m$ until $1^h\ 15^m$ A.M., when the numbers seen fell off most rapidly, *contrary* to the ordinary rule of *horary increase,* until 4 o'clock A.M. As far as I can estimate, the number seen by one person about 1 o'clock must have averaged about 50 in one minute. At $1^h\ 45^m$ I counted 50 in six minutes, and at 3 o'clock only 15 in five minutes!

"There was rather a remarkable glare during the display, and the sky was not nearly so dark as it should have been." (Letter from Mr. Greg).

Report of Mr. Dancer, optician and practical astronomer, of Manchester, to Mr. Greg.—"*Meteors.* Morning of November 14th, 1866, Manchester.

	Interval.	No. of meteors seen.	Remarks.
From $12^h\ 37^m$ A.M. to $12^h\ 53^m$ A.M.	16^m	146	3 observers.
" $12^h\ 59^m$ " " $1^h\ 0^m$ "	62^s	100	2 "
At $2^h\ 15^m$ "	5^m	66	3 "

"The largest seen had a purplish train and colour.

"One gentleman, in a very favourable position in Cheshire, reports fifteen meteors seen at once." (Communicated by Mr. Greg.)

Blackburn, Lancashire.—"At $12^h\ 15^m$ A.M., meteors appeared at the rate of two or three per minute. At 1^h A.M., four or five conspicuous meteors were nearly constantly to be seen in the sky. One observer might, if his view were entirely uninterrupted by clouds, see fifty simultaneously. At $2^h\ 15^m$ A.M. a comparative cessation. At 3^h A.M., only a few weak ones in the space of two or three minutes. At 4^h, 5^h, and 6^h A.M. no further appearances, the sky becoming more permanently overcast, with few glimpses of the stars. Immediately before sunrise, the sky being clear, there were no meteors visible." (From the Manchester 'Examiner and Times.')

Beeston Observatory, Nottingham. Extract from Mr. Lowe's observations:—"The first meteor seen was at $7^h\ 59^m$ P.M., on the N.E. horizon, large and bursting like a rocket. From 8^h until 10^h P.M. much cloud. From 10^h P.M. until 11^h P.M. cloudless, twelve small meteors seen. Between 9^h P.M. and 11^h P.M. six flashes like faint reflected lightning*. At $10^h\ 36^m$ P.M. an indistinct meteor, a mere dull spark, moved from N. to S. horizontally (this was evidently very low down, as a hill behind it was higher than the meteor. It was impossible to be deceived in this, and I consider that it passed within 100 yards of me). The sky was again cloudy until nearly half-past 1 o'clock A.M., but quite light from the meteors.

	h	m			
"About	1	20	A.M. I counted myself	104	in a minute.
at	1	30	" " "	100	"
at	1	50	" " "	80	"
at	3	30	" they had diminished to	6	"
and at	4	30	" " "	4	"

"I watched all through the night before, and we had three different times clear sky of from 20^m to 30^m duration between heavy showers, but not a single meteor was seen; and on the night following the shower, when clear, there were but few seen here."

Oundle.—Report of H. Weightman:—"On the night of the 12th, although keeping a strict watch between $6^h\ 30^m$ and $7^h\ 30^m$ P.M., and again between $8^h\ 30^m$ and $9^h\ 30^m$ P.M., I saw no meteor. I watched again in the open air

* "The lightning flashes had not the looks of lightning. Was it reflected meteor light?"

from 11 P.M. until 5^h A.M., on the morning of the 14th, and recorded the following numbers:—

Hour.	Numbers seen.	Average number per minute.	Remarks.
11^h P.M. to 12^h P.M.	75	1	Some time lost in preparations.
12^h P.M. " 12^h 35^m A.M.......	500	14	Several observers on the watch.
12^h 35^m A.M. to 12^h 50^m A.M.	500	33	" "
(Their number then became too great to admit of being counted.)			
4^h A.M. to 5^h..............	50	1	Several observers on the watch

"A few flashes of sheet lightning occurred at intervals. From 1^h to 1^h 15^m A.M., during which time I should think that the meteors were most plentiful, an intensely dark cloud gradually overspread the heavens, but went off again very quickly. The effect produced by the meteors seen through the breaks was very striking."

Wisbech, Cambridgeshire.—The numbers registered during the night of the 13th–14th, by Mr. S. H. Miller, with the assistance of Mr. J. Kerridge and Mr. T. Williams, were—

Hour, G. M. T.	Number of meteors seen.	Average number per minute.	Remarks.
h m h m			
From 11 0 P.M. to 12 0 A.M.	30	1	Floating clouds in the sky.
" 12 0 " 1 0 "	452	8	" "
" 1 0 " 1 10 "	41	4	A gale of five pounds' pressure springing up with clouds and rain. Meteors in rapid succession seen through breaks.
" 1 29 " 2 0 "	199	7	
" 2 0 " 3 0 "	228	4	Frequent clouds. Lightning was seen, of a ruddy hue.
" 3 0 " 4 0 "	162	3	Floating clouds.
" 4 0 " 5 0 "	45	1	The sky after this became overcast; with rain.
Total number seen	1157		

On the night of the 14th–15th, which was much more favourable for observations, there were few meteors seen.

At *Norwich*.—Report of Mr. J. Crompton, assisted by Mr. R. Pinder:—"Clouds passed constantly from N.W. to S.E. during the evening of the 13th. Lightning was seen near the S.E. horizon, but no thunder was audible. A splendid meteor passed from east to west at 9^h 30^m.

"From 11^h 55^m to 12^h 55^m we counted 193 meteors. Average 3 per minute. At that time the sky was overcast. By 1^h 30^m it was clear in the south (S.E. to S.W.), though still cloudy in the N. and N.E. From 1^h 30^m to 1^h 45^m A.M. we counted 350 meteors at least. Average 23 per minute. They appeared in rushes of 3, 4, or 5 at once. Several were visible through the fleecy clouds. Had the sky been clear all the time, I verily believe that we should have counted thousands. Gathering clouds drove us in with rain, at 2^h 15^m A.M. However, at a later hour it cleared somewhat, and I saw several more following the tracks of their predecessors."

At *Aylsham*, Norfolk.—Mr. W. H. Scott reports that on the morning of the 14th, "at 1^h 15^m A.M. there was for about 10 minutes a perfect shower of

meteors. In 60 seconds I counted 28, although my place of observation was shut in by a house on one side. The least number that I counted in 60 seconds during the time mentioned was thirteen. A dense cloud then came over from the N.W., and I could see no more. They were quite observable through the edges of the cloud when it first came over."

At *Wimbledon.*—A record of the number of the meteors was kept, with other particulars of the shower which will be given later on, by Mr. F. C. Penrose, assisted by one other observer. The names of the observers are indicated by the letters F. and H. in the register.

Hour of observation, G. M. T.	Interval, in minutes and seconds.	Number of meteors seen by the observers F. and H. looking	
		South.	North.
h m s	m s		
From 12 57 20 to 12 59 50	2 30	33. H. Sky partially cloudy.	51. F. Sky clear.
From 1 1 5 to 1 2 40	1 35	24. H. Sky considerably cloudy*.	50. F. Sky clear.
From 1 10 20 to 1 12 5	1 45	19. F. Sky much clouded.	100. H. Sky clear. Number by estimation (many more than were *counted*).
From 1 16 50 to 1 18 20	1 30	53. F. Sky nearly clear.	81. H. Sky clear.

At *London.*—On the top of Primrose Hill, Mr. T. Crumplen, assisted by Mr. H. J. Wix, recorded the number of meteors seen during the shower. The sky was absolutely cloudless. A bright auroral glare spread itself over the north and north-eastern sky between 10^h and 11^h P.M., sufficiently luminous to obscure the fainter stars. Occasional sheet-lightning was observed during the progress of the shower. The observers looked in opposite directions, and counted audibly to prevent reduplication.

Hour of observation, Nov. 14th, A.M.	Interval in minutes.	Number of meteors seen by		Total in all parts of the sky	Average number per minute.
		Mr. Wix, looking S.	Mr. Crumplen, looking N.		
h m					
From 12 25 to 12 35	10	196	225	421	42
From 2 7 to 2 17	10	69	80	149	15

The above numbers, in both cases, appear to show that more meteors were visible in the northern than in the southern half of the sky. The maximum was reached between 1^h and 1^h 15^m A.M., when 103 meteors were counted in 90 seconds in a space not exceeding one-third part of the sky, in a N.W. direction.

* After this time the observers changed places. During the interval from 1^h 40^m to 2^h A.M. there was a comparative absence of meteors. Soon afterwards the sky became much overcast.

At *Hawkhurst*, Kent.—After midnight, on the morning of the 14th, the sky was nearly cloudless. One observer, looking towards the north,

From $12^h\ 0^m$ to $12^h\ 5^m$ A.M., counted 25 meteors. Average 5 per min.
From $12^h\ 48^m$ to $12^h\ 50\frac{1}{2}$ A.M., „ 68 „ „ 27 „

Flashes, like faint lightning behind a small cloud, occurred at $12^h\ 35^m$ A.M., and another later on. A third was seen about $2^h\ 30^m$ A.M., which could not be traced to any spot.

At *Cowes*, Isle of Wight.—Report on the meteors of the 13th–14th of November 1866. ("The Times," Nov. 16th.)

Hour of observation.		Interval, in minutes.	No. of meteors seen.	Average No. per minute.	Remarks.
From	To				
h m	h m				
11 30	12 0	30	66	2	
12 0	30	30	200	7	
30	50	20	201	10	
50	58	8	190	24	
58	1 2	4	201	50	
2	5	3	206	70	
5	10	5	214	42	
10	11	1	100	100	
11	13	2	206	103	Rate of apparition now too great for the meteors to be counted for some minutes.
1 50	1 54	4	83	21	At $1^h\ 30^m$ rain fell sharply.
2 20	2 35	15	73	5	Rain fell again during the last interval.
at	3 15	......	......	2 or 3	
at	5 0	......	none seen	......	

At *Sidmouth*, Devonshire.—Report of Mr. H. S. Heinecken on the meteor-shower of the 13th–14th of November 1866.

The sky was overcast, with frequent showers, until $12^h\ 8^m$ A.M., and again from a quarter before one to one o'clock. At one o'clock it cleared for about ten minutes, and after this it only cleared again at intervals throughout the night. Three observers looked due north, east, and south, through the closed, sloping windows of an observatory, which exactly faced in those directions, and obtained the following enumerations:—

Hour of observation, Nov. 14th, A.M.		Interval, in minutes.	No. of meteors seen.	Average No. per minute.	Remarks.
From	To				
h m s	h m s	m s			
12 8 10	12 45 0	36 50	457	12	Three observers, looking N., E. and S.
1 0 0	1 10 0	10	130	13	Two observers only, looking E. and S.
3 10 0	3 20 0	10	31	3	Do.

At $5^h\ 10^m$ A.M. the sky was suddenly illuminated by a flash of lightning; but the light was of longer duration, and the meteor (if such was the cause of it) was not seen.

Bathwick Hill, Bath.—Report of Mr. W. Dobson, on "Meteors observed at Bath. Nov. 14th, 1866."

Hour of observation, Nov. 14th, A.M. From	To	Interval, in minutes.	No. of meteors seen.	Average No. per minute.	Remarks.
h m	h m				
12 0	12 15	15	75	5	
15	30	15	124	8	
30	43	13	221	15	
1 5	1 10	5	222	44	Sky overcast with clouds since the last interval.
10	15	5	260	52	
15	20	5	214	43	
20	25	5	163	33	
25	30	5	103	21	
30	35	5	62	12	
35	40	5	60	12	
40	45	5	44	9	
45	50	5	43	9	
50	2 0	10	35	7	
2 0	5	5	45	9	
5	10	5	44	9	
10	20	10	24	5	

The numbers were counted by Mr. Dobson when not occupied with observations at the telescope; when thus employed, another observer took up the numbers, and continued to register the meteors.

At *Birmingham.*—Report of Mr. W. H. Wood on the November meteors of 1866, at Birmingham.

"Numbers counted in one-third of the heavens, containing the radiant-point, by Mr. Wood, observing singly.

Date.	Hour of observation, Nov. From	To	Interval, in minutes.	No. of meteors seen	Average No per minute.	Remarks.
	h m	h m				
13	10 41 P.M.	11 15 P.M.	34	8	0	Paths and particulars mostly noted.
	11 15	34	19	2	0	Amount of cloud $\frac{1}{8}$. Lightning in N. at 10^h 57^m.
	34	55	21	6	0	Amount of cloud $\frac{3}{4}$.
	55	12 0 A.M.	5	1	0	Overcast, rain. Cloud $\frac{8}{10}$.
14	12 0 A.M.	10	10	9	1	Cloud $\frac{1}{4}$.
	10	22	12	16	1$\frac{1}{8}$	Then cloud, $\frac{3}{4}$.
	22	26	4	9	2	Cloud, $\frac{2}{10}$.
	26	28	2	8	4	
	28	33	5	34	7	Sky clear, and remained so till 2^h 25^m, then cloudy. The rate of apparition is now so great, that only special phenomena are recorded.
	33	36	3	21	7	
	36	39	3	32	11	
	39	43	4	52	13	
	43	45	2	37	18	
	45	56	11	255	23	
	1 25	1 29	4	87	22	
	35	41	6	60	10	
	41	47	6	56	9	
	55	57	2	16	8	
	57	2 4	7	18	2$\frac{1}{2}$	[in N.
	2 10	14	4	10	2$\frac{1}{2}$	Sky hazy. Clouds gathering
	20	23	3	5	1	Cloudy. Observations discontinued.

"Number of meteors seen, in half hours, in a third part of the sky.

	h m	h m	h m	h m	h m	Total.
In the half hour ending	12 30	1 0	1 30	2 0	2 30	
Number of meteors seen	56	510	684	308	70	1628
Estimated, *for all* the sky	170	1540	2050	920	210	4890

"Time of Max., 1^h 0^m A.M.—1^h 25^m A.M., No. *for all parts,* not less than 70 p. min.
Hour of Max., 12^h 30^m A.M.—1^h 30^m A.M., ,, ,, 3590 meteors."

At *Aberdeen.*—Report of Mr. D. Gill to Professor Grant, on the meteors of the evening of Tuesday the 13th of November, and morning of Wednesday the 14th of November 1866.

"Two observers took their stations at 10^h P.M.

"The evening was beautifully clear. A low bank of clouds surrounded the horizon to a height of 3° or 4°; but this soon cleared off.

"A breeze from the west became stronger as the night advanced, but no cloud appeared until 2^h 30^m on the morning of the 14th, and by 3 o'clock the sky was totally obscured. Aurora was visible in regular rays from the north.

"From the accompanying journal, giving details of observations up till 12^h $48\frac{1}{2}^m$ A.M., it will be seen that the number of meteors seen in the previous minute was 200.

"From this time meteors, generally with nuclei of the brilliancy of Venus, and apparently emanating from Leo, shot out in all directions in such great numbers as to defy computation.

"By 1^h 30^m the numbers had so fallen off that from that moment 100 were counted in 3^m 57^s (about 25 per minute), and at 2^h the same number in 5^m 20^s, or a little less than twenty per minute. The following is a list of the numbers visible as observed:—

Evening of 13th November.			
Hour of observation, P.M. From	Hour of observation, P.M. To	Total No. from 10^h P.M.	Number in 15 minutes.
h m	h m		
10 0	10 15	2	2
10 15	30	5	3
30	45	10	5
45	11 0	17	7
11 0	15	29	12
15	30	38	9
30	45	53	15
45	12 0	85	32

At 1^h 30^m A.M., av. rate per min 25.
,, 2^h 0^m ,, ,, ,, 20.

Morning of 14th November.			
Hour of observation, A.M. From	Hour of observation, A.M. To	Total No. from 10^h P.M. on the 13th.	Average rate of apparition per minute.
h m s	h m s		
12 0 0	12 7 30	100	3
7 30	18 30	200	9
18 30	24 30	300	17 } uniform.
24 30	30 30	400	17 }
30 30	34 0	500	30 } uniform.
34 0	37 30	600	30 }
37 30	40 0	700	40
40 0	45 30	900	45
45 30	47 30	1000	50
47 30	48 30	1200	200

"A very striking feature is the markedly rapid increase compared with the gradual decrease. A curve representing the observations would indicate bands, or periods of uniform numbers."

At *Glasgow.*—After midnight, until 1 o'clock, passing clouds from the west occasionally obscured the sky. From 1 o'clock until after 3 o'clock A.M., the sky was perfectly free from clouds. The rate of apparition of the meteors was registered at intervals throughout the shower by Professor Grant, as given in the subjoined list. Some notes of their numbers from Mr. Herschel's observations are also placed in the register, and are denoted by the letter H. Those numbers observed by Professor Grant are designated by the letter G.

Hour of observation, A.M.	No. of meteors per minute.	Hour of observation, A.M.	No. of meteors per minute.	Hour of observation, A.M.	No. of meteors per minute.
h. m.		h. m.		h m	
12 15	2 estimated. H.*	1 10	56 counted. H.	1 35	21 counted. H.
12 45	12 do. H.*	1 15	57. G.	2 4	13. G.
1 0	25 do. H.*	1 20	43. G.	2 34	3 in 2^m count. H.
		1 25	30. G.	3 0	2. G.
		1 30	43 in 2^m. G.	4 30	1 in 2^m or 3^m. G.

At about 12^h 30^m A.M. an extremely vivid flash of lightning was observed, which could not be traced to any cloud, nor to any meteor then visible in the sky. The last observations were made at 5 o'clock A.M., and the heavens had then resumed their normal aspect.

At *Sunderland*, Durham.—Report of Mr. T. W. Backhouse on the November meteors, 1866, as seen at Sunderland.

"I looked out for meteors now and then on the morning of the 13th, but saw none. It was mostly cloudy.

"On the evening of the 13th I looked out frequently for meteors until after 10^h P.M., but saw only one, at 8^h 23^m.

"On the following morning I watched from 12^h 15^m to 3^h 35^m A.M. The night was splendid, though there were often small clouds; but I do not think that they at all affected the number of the meteors that I counted. It was windy. I saw a flash of distant lightning, unless it was the light of a meteor below the horizon. There was a very faint aurora of an irregular kind. I counted the meteors now and then, and saw

a out of a S.W. window.

b out of an E. window, which commands not quite so much of the sky as the S.W. window.

c, *d*, *e* out of doors; *c* looking towards γ Geminorum; *d* towards Capella; and *e* in different directions.

"The most that I ever counted visible at once was six meteors. It was between 12^h 52^m and 12^h 53^m A.M. At 12^h 31^m I first saw three at once."

Hour of observation, Nov. 14th A M		Interval in minutes and seconds.	Number of meteors seen. *a b c d e*	Average rate per minute. *a b c d e*
From	To			
h m s	h m s	m s		
12 32 0	12 34 45	2 45	.. 20	. 7........
39 0	40 45	1 45	40	23.. ....
52 0	53 0	1 0	25..	25........ ...
1 8 25	{ 1 10 5 or ? 9 5†	1 40 or ? 0 40†	} 41.	} 25 (or ? 61†)
26 53	27 57	1 4	31.	29.... . ...
29 50	31 10	1 20	.. 30. . . .	.. 22 ....
34 35	35 35	1 0	..... 35. ...	... 35 ....
42 50	45 3	2 13	.. .. .. 30...	.. . ... 14...
52 0	57 0	5 0	 39	 8
2 26 25	2 28 45	2 20	10..	4...........
3 4 33	3 8 0	3 27	10	3..... .. ...
15 0	18 45	3 45	.. 11..	. 3.........
31 45	33 35	1 50	4	2...........
6 16 0‡	6 18 45	2 45	1...........	0·4 ....

* These numbers were recorded, from recollection of the appearance of the meteors, immediately after the cessation of the shower.

† Conflicting journal entries make this statement doubtful.

‡ Approaching twilight made stars below the third magnitude invisible.

At *Flimwell, Hurstgreen*, Sussex.—Mr. Howlett obtained an uninterrupted view of the shower from an elevated situation near his residence, with a perfect view of the horizon on all sides. The numbers which he reckoned, although higher than those of the foregoing estimates, were fairly counted, and indicate the time of the maximum with considerable precision. Two observers looking towards opposite directions counted aloud to prevent reduplication, and as each counting of meteors was registered, the time by a chronometer was taken as nearly as possible. The error of the chronometer, if any, can hardly have exceeded one minute.

Date, 1866, Nov.	Hour of observation, G.M.T.	Interval, in minutes and seconds.	Number counted in the interval.	Average rate per minute.	Date, 1866, Nov.	Hour of observation, G.M.T.	Interval, in minutes and seconds.	Number counted in the interval.	Average rate per minute.
	h m s	m s							
P.M. 13th	11 54 0				A.M. 14th	5 30	0 30	100	200
	to					6 30	1 0	100	100
A.M. 14th	12 14 30	20 30	100	5		7 30	1 0	100	100
	20	5 30	50	9		8 0	0 30	100	200
	26	6 0	50	8		8 30	0 30	100	200
	30	4 0	100	25		9 30	1 0	100	100
	35	5 0	100	20		10 0	0 30	100	200
	39	4 0	100	25		11 30	1 30	100	66
	42	3 0	100	33		12 30	1 0	100	100
	45*	3 0	100	33		14 30	2 0	100	50
	46 30	1 30	100	66		15 30	1 0	100	100
	48	1 30	100	66		16 30	1 0	100	100
	50	2 0	100	50		18 0	1 30	150	100
	51 30	1 30	100	66		19 0	1 0	100	100
	52 30	1 0	100	100		20 30	1 30	200	133
	54 0	1 30	100	66		25 0	4 30	250	56
	55 0	1 0	100	100		26 30	1 30	100	66
	56 0	1 0	100	100		28 0	1 30	100	66
	58 0	2 0	100	50		32 0	4 0	100	25
	59 0	1 0	100	100		51 0	19 0	500†	53
	1 1 0	2 0	100	50		55 0	4 0	100‡	25
	2 0	1 0	100	100		2 3 30	8 30	100	12
	2 30	0 30	100	200		15 0	11 30	100	9
	3 0	0 30	100	200		27 30	12 30	100	8
	4 0	1 0	100	100		2 40 0	12 30	100	8
	5 0	1 0	100	100					

The watch was then suspended until $4^h\ 5^m$ A.M.

A.M. 14th	4 5 0				A.M. 14th	17 0	7 0	20	$2\frac{6}{7}$
	to					28 0	11 0	19	$1\frac{8}{11}$
	29 0	24 0	50	$2\frac{1}{12}$					
	52 0	23 0	50	$2\frac{1}{6}$					
	5 10 0	18 0	20	$1\frac{1}{9}$					

The numbers projected on a curve (fig. 1) show that the observer's station traversed the richest portion of the zone of meteors between $1^h\ 2^m$ and $1^h\ 10^m$ A.M. on the morning of the 14th of November 1866; and that lesser max-

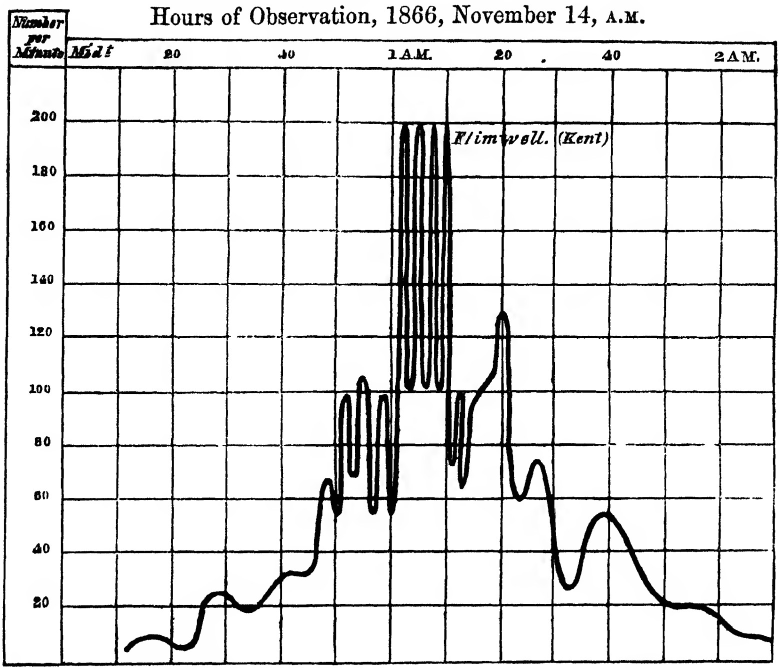
* From this time attention was almost exclusively confined to merely counting the meteors without continuing to record their apparent paths amongst the stars.

† These 500 were counted by one observer during the other's absence. Two observers might have counted 1000, or 53 per minute.

‡ Began again to have time to record the apparent paths of the meteors amongst the stars.

ima of the display also occurred about $12^h\ 50^m$, $1^h\ 20^m$, and $1^h\ 40^m$ A.M. during the progress of the shower.

Fig. 1.—Rate of apparition per minute of meteors observed by Mr. Howlett at Flimwell, near Hurst Green in Sussex, on the morning of the 14th of November 1866, with one assistant.



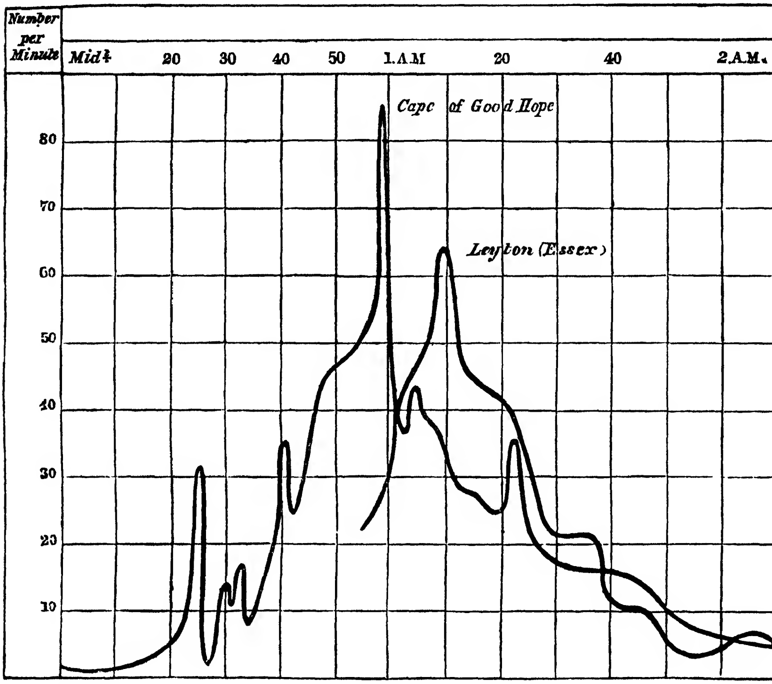
At *Leyton*, Essex.—The total numbers of meteors and their average frequency per minute, in successive five minutes on the morning of the 14th of November 1866, as observed at Mr. Barclay's observatory at Leyton, are thus stated by Mr. Talmage:—

In the five minutes ending at	Total number counted	Average number per minute.	In the five minutes ending at	Total number counted.	Average number per minute.
h m			h m		
Nov. 14th 12 57 A.M.	115	23	Nov. 14th 1 37 A.M.	109	22
1 2	125	25	42	57	11
7	231	46	47	55	11
12	324	64	52	31	6
17	239	47	57	22	4
22	214	43	2 2	28	6
27	147	29	7	37	7
1 32	104	21	2 12	20	4

The numbers projected, like the former, in a curve show that the greatest frequency of the meteors at Leyton, on the morning of the 14th of November 1866, took place at very nearly ten minutes after one o'clock, and that ten-

dencies to other maxima were observed at twenty minutes and thirty-five minutes after one, agreeing nearly with the previous curves.

Fig. 2.—Average rate per minute of meteors observed at the Cape of Good Hope, and at Leyton, in Essex, November 14th, A.M., 1866.



At the *Cape of Good Hope*.—Royal Astronomical Society's 'Monthly Notices,' vol. xxvii. p. 66. The meteoric shower was well observed at the Royal Observatory, and described by Mr. G. W. H. Maclear, commencing at $1^h\ 3^m$ A.M. (Cape time), and reaching its maximum between $2^h\ 10^m$ and $2^h\ 13^m$ A.M., when in three minutes 200 meteors were observed.

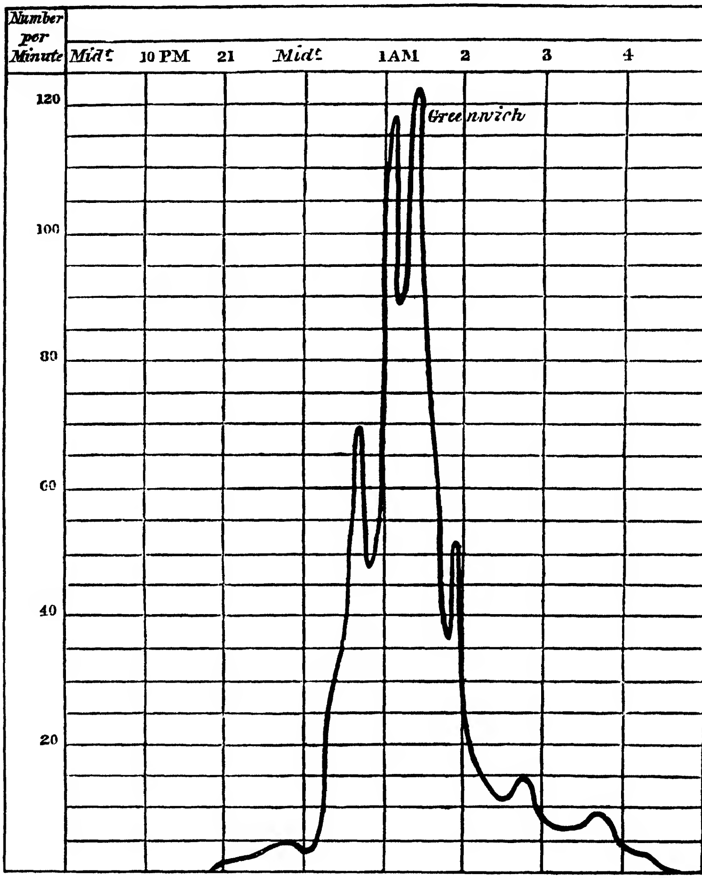
Deducting $1^h\ 13^m\ 55^s$ (long. of the Cape of Good Hope Observatory, E. from Greenwich) from the hours of observation, and projecting the numbers of the Cape register, like the foregoing numbers, in a curve, it is seen (fig. 3) that the maximum at the Cape of Good Hope took place, in point of absolute time, about thirteen minutes earlier than at Leyton; and the other inflections of the curve at the Cape of Good Hope are displaced from those at Leyton by about an equal interval. Mr. G. Forbes, of St. Andrews University, accounts for the difference* by showing that, in the relative position of the earth with respect to the zone of meteors on the morning of the 14th of November 1866, the Cape of Good Hope would touch their boundary, and would become plunged into the thickest portion of their stream *about thirteen* minutes before the same phenomena would be perceived in England.

At *Greenwich*.—Royal Astronomical Society's 'Monthly Notices,' vol. xxvii. p. 54.—The rate of frequency of meteors per minute at the Royal Observa-

* Philosophical Magazine, S. 4. vol. xxxiii. p. 282.

tory, Greenwich, during the night of the 13th–14th of November 1866, was recorded by a party of eight observers under the direction of Mr. Glaisher. The diagram (fig. 3) shows, in the same manner as the preceding, the average

Fig. 3. Hours of observation, 1866, November 13–14.



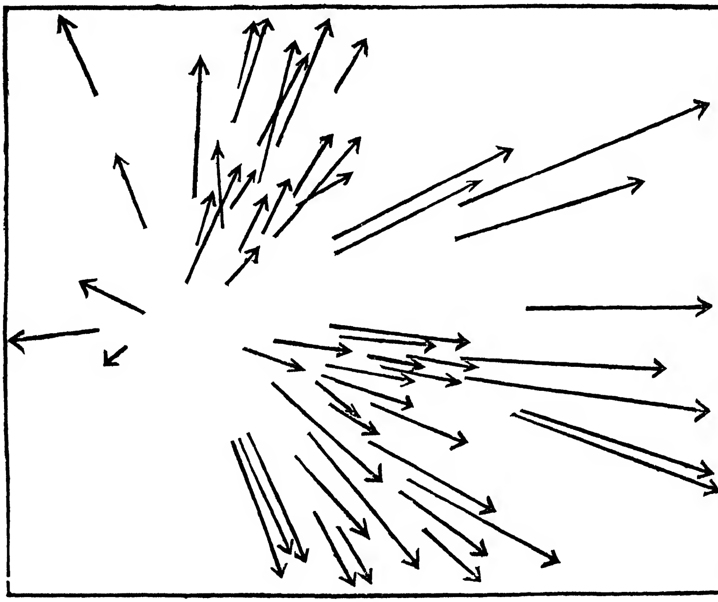
number of meteors per minute observed at Greenwich, on the 13th–14th of November, between the hours of 11 P.M. and 4 A.M. Besides four principal maxima of frequency at $12^h\ 40^m$, $1^h\ 10^m$, $1^h\ 20^m$, and $1^h\ 50^m$ A.M., two other smaller maxima are seen to have occurred at $2^h\ 45^m$ and $3^h\ 45^m$ A.M. The Greenwich observations, *in extenso*, are printed in the Greenwich 'Results of Magnetical and Meteorological Observations' for the year 1866.

At the Royal Observatory, Greenwich, Mr. J. W. L. Glaisher recorded a number of the apparent paths of the meteors, amply sufficient to determine the positions of the principal radiant-point in Leo, and of two others of less consequence, one in Gemini and the other in Perseus.

Among the tracks of meteors recorded by Mr. Glaisher's staff of observers at the Royal Observatory, about sixty of the apparent paths were projected

on a general chart of the constellations (see figure)* specially provided by the Committee of the British Association for this purpose, with a view of de-

Tracks of Meteors observed at the Royal Observatory, Greenwich, 1866, November 13–14.



termining the exact position of the radiant-point. The tracks prolonged backwards, with very few exceptions, pass across a small circular area, about 10° in width, having its centre near the star *x* Leonis, about ½° north of that star in right ascension 148° 50′ (9h 55m), N. Decl. 23°. The position of the small star *x* Leonis (Bode) is the identical place assigned to the radiant-point of the great November shower, in the year 1833, by Professor Twining.

At *Glasgow*.—The tracks of eighty-three meteors recorded between the period of the greatest intensity of the shower at 1h 15m A.M. and 2h 40m A.M. were projected by Mr. Herschel, with the assistance of Mr. A. Macgregor, on a similar chart, and indicate nearly the same position of the radiant-point in R. A. 149° (9h 56m), N. Decl. 24°†. Professor Grant, by means of the same star-chart and with forty-three alineations, obtained for the position of the radiant-point R. A. 147° 35′ (9h 50m), N. Decl. 22° 53′; while his assistant, Mr. J. Plummer, with the projections of twenty-six alineations on the same map, found the position of the radiant-point in R. A. 150° 30′ (10h 2m), N. Decl. 21° 36′. Allowing twice the weight to the former determination, the definitive position of the radiant-point that results from both of these observations combined is in R. A. 148° 33′ (9h 54m), N. Decl. 22° 30′. A list of fifteen of these positions of the radiant-point are given by Mr. Herschel in

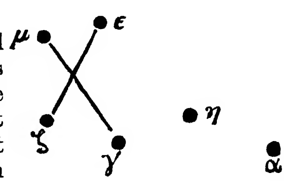
* Diagram at p. 55, vol. xxvii. of the 'Monthly Notices' of the Royal Astronomical Society.

† Diagram at p. 56, vol. xxvii. of the 'Monthly Notices' of the Royal Astronomical Society.

the 'Monthly Notices' of the Royal Astronomical Society, vol. xxvii. p. 19 *, of which this and the following paragraphs contain the original descriptions.

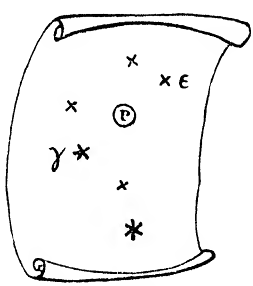
At *London.*—Mr. T. Crumplen and Mr. S. H. Wix report:—"Watching carefully at $12^h\ 45^m$ to $1^h\ 15^m$, and indeed at other times throughout the morning, we came to the conclusion that the radiant was in the space contained between the stars ζ, x, μ, ϵ Leonis, at a spot indicated on the Chart of the British Association as R. A. 147°, N. Decl. 24°. This was arrived at by observing meteors in the immediate neighbourhood of those stars, some of them coming almost from the very point itself, and visible only as enlarged stars with scarcely any perceptible train."

Report of H. McLeod:—"I only noticed four meteors from other points; but the principal radiant-point was most clearly defined.



"The figure represents the six stars in Leo; and the radiant-point appeared to me to be as near as possible to the intersection of lines joining the opposite stars of the trapezium. One very bright one appeared about $2^h\ 15^m$ A.M., just to the right of the radiant-point, and burst, leaving a green spot which lasted about half a minute."

At *Wimbledon.*—Mr. F. C. Penrose states that "the origin or radiant-point in Leo was clearly between γ and ϵ; but I question if a single point gives a satisfactory origin, and I submit that a circle of about 3° in diameter is more consistent with the direction of the paths of the meteors, as P in the figure."



At *Hawkhurst.*—Sir John Herschel laid down the position of the radiant-point with great precision on Bode's chart of the constellation Leo on the morning of the 14th of November, and found its "longitude for $1866\frac{3}{4}$ (allowing 55′ for precession since 1801, the epoch of the chart) to be 142° 20′, and its latitude 10° 15′ North." (Monthly Notices of the Royal Astronomical Society, vol. xxvii. p. 20.)

At *Freshwater*, Isle of Wight.—Mr. Pritchard, the President of the Royal Astronomical Society, in a letter to Mr. Herschel states that on the 14th of November he marked the radiant-point thus, {⊙ Nov. 13, 1866}, "at x Leonis (the least bit above it). I should say that it was too plain to admit mistake to those who looked long enough."

At *Clifton*, Somersetshire.—In a letter to 'The Times' (of November 15th) Mr. G. F. Burder writes:—"It was especially interesting to watch the meteors which took their origin in the immediate neighbourhood of the centre from which they all radiated. With the aid of these, it was easy to determine with exactness the radiant-point. This spot was in a line between γ and μ Leonis, about 3° from the former, and $5\frac{1}{2}$° from the latter star."

At *Birmingham.*—Mr. Wood's report, under the head of General Remarks,

* Two *errata* in that paper require correction. The positions there *excluded* from the final average are Nos. 6, 10, 11, and not Nos. 9, 10, 11, as stated. The final average in the paper is the *arithmetical mean* of the remaining twelve positions in R. A. and declination, *giving equal weight to every point*; and not, as there stated, the centre of a small circular area containing them.—A. S. H.

contains a description of phenomena at the radiant-point. "Stationary objects continually appeared at a point situated in the centre of the quadrilateral $\gamma, \zeta, \mu, \epsilon$ Leonis, at R. A. 148°, N. Decl. 25°; and these appeared as blue nebulous patches 3′ or 4′ in diameter. Meteor-streaks within a circle of 4° radius round this point appeared more compact and brighter than those observed elsewhere."

A printed account of the meteoric shower by Mr. D. Smith describes the radiant-point, or point from which the meteors emanated, as most clearly and beautifully kept. "This point was, in the present instance, about the centre of the 'sickle' in the constellation Leo."

At *Beeston Observatory*, Nottingham.—Mr. Lowe reports that "At $2^h\ 1^m$, and again at $2^h\ 9^m$, and at $4^h\ 31^m$ A.M., meteors appeared on the exact radiant-point in Leo, blazed out, and died away without moving. I traced sixty meteors to ascertain the exact point, and I made it nearer ϵ than η Leonis. If a line were drawn from α to μ, and another from γ to ϵ Leonis, where those two lines cut each other I conceived the point was close to."

At *Wisbech*, Cambridgeshire.—Mr. S. H. Miller briefly describes the radiant-point thus:—"The point of radiation was manifest from the first. I should fix the radiant-point between γ and ζ of Leo."

At *Manchester*.—Mr. Greg considered that the radiant-point, "though not a mathematical centre-point, was very closely round the star ζ Leonis, extending from γ Leonis towards e Leonis Minoris."

At *Sunderland*.—The position of the radiant-point was determined with care by Mr. Backhouse, who states that "the meteors belonged to two classes. Class I. These radiated from Leo. I carefully traced back the courses of fifty-four of them, and found the radiant-point to be R. A. $9^h\ 57^m$ (148° 15′), N. Decl. 23° 50′. But tracing it only from those in and near Leo, between $12^h\ 30^m$ and $2^h\ 8^m$ A.M., it seemed to be R. A. $9^h\ 56\frac{1}{2}^m$ (149° 15′), N. Decl. 23° 15′; and from those in and near Leo between $2^h\ 8^m$ A.M. and $3^h\ 35^m$ A.M.; R. A. $9^h\ 58\frac{1}{2}^m$ (149° 37′), N. Decl. 22° 45′."

Mr. J. Crompton reports from Wisbech, Cambridgeshire:—"It seemed as if we could mark out in the sky the path that they would take, or almost hang wires for them to run upon, so regularly did they pass over, in lines converging backwards over a space in or about Leo. I think that we noticed only three which took any other or opposite direction."

The point of radiation during the principal part of the display on the morning of the 14th of November 1866, was observed in France, at Metz, by M. C. M. Goulier, who frequently projected it from comparison with the sky upon the planisphere of Chazallon. Corrected for precession since the date of the map (1850·0), the coordinates of the position of the radiant-point were R. A. 149·5 ($9^h\ 58^m$), N. Decl. 23°. M. Goulier adds that "the uncertainty attaching to this position of the radiant-point is certainly less than one degree." (Comptes Rendus, December 1866.)

Brightness of the Meteors.

Mr. F. C. Penrose, at Wimbledon, Surrey, reports on the morning of the 14th, that "at $1^h\ 20^m$ A.M., or thereabouts, a very bright meteor passed towards the south-west and produced a very sensible reflected light. Neither F. or H. saw the meteor, but only the reflected light. On looking up, the train was distinctly seen, and remained visible for at least two minutes by estimation.

"H. recorded one meteor, only, which was clearly brighter than Sirius; and F. questions having seen any brighter than Sirius. That above men-

tioned (which was made known by its reflected light alone) may have approached the maximum brilliancy of Venus."

The meteor which appeared over Scotland at 2^h 41^m A.M., as seen by observers watching the meteors from the top of Carlton Hill, threw their shadows on the ground. It was the reflected light, also, which first drew Mr. Gill's attention to it at Aberdeen.

A writer in the 'Newcastle Chronicle' states that "sometimes, when two or three large meteors would fall straight down in a parallel course leaving long streams of light behind them, a greenish glare was cast around."

The scale of brightness of eighty-three considerable meteors, whose apparent paths were recorded at the Glasgow Observatory by Mr. Alex. S. Herschel, assisted by Mr. A. Macgregor for the purpose of determining the radiant-point, was as follows:—

As bright as Jupiter, or brighter..	2 meteors	= 3	per cent.
,, Sirius	14 ,,	= 17	,,
,, 1st-mag. star	39 ,,	= 48	,,
,, 2nd-mag. star......	26 ,,	= 32	,,

The report of Mr. Backhouse at Sunderland contains a similar estimate of their brightness.

"About 1^h 50^m A.M. I tried to ascertain the proportion of meteors of different magnitudes, with the result below:—

Brighter than 1st-mag. star....	2	= 7	per cent.
= 1st ,, ...	4	= 14	,,
= 2nd ,, ...	5	= 17	,,
= 3rd ,, ...	6	= 20	,,
= 4th ,, ...	8	= 28	,,
= 5th ,, ...	4	= 14	,,
Total......	29	100	

Mr. Baxendell, at Manchester, gives the following enumeration:—

Out of every 100 meteors, 10 were above the 1st mag.; the brightest of these were two or three times brighter than Sirius:

15	were between	1st and	2nd mag.
25	,,	2nd ,,	3rd ,,
30	,,	3rd ,,	4th ,,
15	,,	4th ,,	5th ,,
5	were below the 5th mag.		
100			

Mr. S. H. Miller reports at Wisbech, Cambridgeshire:—"With very few exceptions, those I registered were equal to stars of the 1st or 2nd magnitude, but some were as bright as Sirius."

Colours of the Meteors.

Mr. Birmingham, at Tuam, describes the meteors as "having the nuclei generally red or deep orange, while the tails were greenish blue."

Mr. V. Fasel, at Dr. Wrigley's Observatory at Clapham, describes the nuclei as "yellow, orange, and sometimes red, while the luminous paths were of an emerald green, or bluish hue, though in some cases red."

Mr. Hugh Weightman, at Oundle (Notts), reports that "the colour of the nuclei, from being a mixture of red, green, purple, and yellow, became

gradually a bright reddish yellow, and the trains, even after the nuclei became yellow, were generally green."

The writer in the 'Newcastle Chronicle', already mentioned, states that the meteors "moved across the sky, leaving in their track, lines sometimes of greenish light, and sometimes of a dull red colour."

Mr. Howlett, at Flimwell (Kent), states that "the nuclei were mostly bluish white, except when near the horizon they appeared of an orange or ruddy tint. The trains were generally of a greenish-white hue, except for the last two degrees or so, which at the moment of explosion assumed a ruddy appearance."

Mr. Lowe reports, at Beeston, near Nottingham, that "the great number of large meteors, on the S.E. horizon up to 15° altitude, were mostly orange-red, whilst those between Leo and the north were bluish white."

Mr. J. Crompton states, at Norwich:—"The colours of the nuclei were mostly white, blue, metallic-green, and sometimes a coppery red. One which I saw cross the foot of Ursa Major was marked as changing its colour from whitish blue to red."

An observer at Hawkhurst (Kent), reports that "the brighest colours, whether of head or streak, appeared in those which were nearest to the radiant-point. One brilliant one at that place, seen by four or five of us, turned pure mauve [lilac] colour before it exploded."

At Saragossa, in Spain, "The meteors all left a well-defined tail or track of sparks of a pale bluish colour, and they finally exploded with a brilliant white or yellow flame; in some instances the flame appeared tinged on the edges with a vivid emerald-green colour, and others exhibited tints of pink or crimson and blue."—(The Times, Nov. 19.)

Mr. T. Crumplen states, in his report of observations made on Primrose Hill with Mr. S. Wix:—"We saw a number of meteors differing in colour, some of a gold or copper tint, some quite ruddy; *but the very great majority* were brilliant white or blue, resembling the electric light.

"The prevailing tinge of the trains was decidedly green." In his letter to the 'Evening Standard (Nov. 15th), Mr. Crumplen also remarks, that "the general colour of the nuclei was of a pale blue, while a brilliant pea-green marked the trains."

Amongst other observations at Cambridge, Professor Challis records, that "a circumstance, which I had not noticed at the August period, was a blue or green appearance of several of the trains, with heads of a ruddy colour. Some few of the heads also were thought to be blue."—(Monthly Notices, R.A.S., vol. xxvii. p. 77.)

Mr. Greg, at Manchester, considers that "the prevalent colour of the meteors was a dull white. . . . . I saw one fine green one, with a defined disk, near the radiant-point, about $12^h\ 30^m$, which began with a brilliant nucleus, and another crimson and green; and I fancy that I occasionally perceived a very slight bluish tinge in the trains."

Mr. H. S. Heinecken, observing at Sidmouth, states that "almost invariably the colour of the head was ruddy. The trains of by far the greater proportion were greenish blue; some of them more intense greenish blue, and more compact and less powdery than others. The green was not unlike the combustion of silver by the galvanic current."

At the Cape of Good Hope Observatory the shower was noticed by Sir Thomas Maclear as consisting of "orange-coloured meteors, leaving streaks of green, mingled with ordinary-looking shooting-stars." (Edinb. Quarterly Review for January 1867.) Mr. G. W. H. Maclear considered "the

prevailing colour [of the nuclei] to be orange, with a long sea-green train. Others were of a deep red, like balls of fire, without any train at all."

Mr. D. Gill, at Aberdeen, further noticed that the trains, "which at first were of a bluish or yellow colour, changed into a beautiful emerald-green."

At Clifton, Mr. G. F. Burder particularizes the colour of the trains as being "of a most delicate greenish hue. This greenish tint was very constant. The meteors themselves, on the contrary, had often a ruddy glow; and in cases when the path was very much foreshortened to the eye, and both trains and meteor could therefore be seen in opposition, the contrast between the colours of the two was very remarkable." (The Times, Nov. 15.)

At Chesham, Bucks, according to the report of Mr. C. Grover, "Most of the meteors exhibited a decidedly red head, with a bluish-green train. I noted that their altitude had a great influence on their colour, those on the horizon being much more tinted than those in the zenith, where some of the brightest looked nearly white, with blue trains. Their position, with regard to the radiant-point, also greatly influenced their colour. Those whose paths were considerably foreshortened, in and about Leo, showing brilliant colours, the red head and greenish train being strongly contrasted, while those with long trains in the west were comparatively pale in colours."

Spectroscopic Observations.

At the Royal Observatory, Greenwich, Mr. Carpenter of the Astronomical Department of the Observatory, and Mr. Nash of the Meteorological Department, had spectroscopes, but neither detected any luminous or dark lines in the spectra of any of the meteors, or of their trains; not even the sodium line found by Mr. Herschel in some of the August meteors.

The rapid cessation of the shower, and the desirability of filling up a chart of meteor-tracks for determining the radiant-point during the brief time that it lasted in what was at first considered to be the earliest part of its display, was the reason why no extensive observations with the meteor-spectroscope were made at Glasgow by Mr. Herschel and Mr. A. Macgregor. The following observations were recorded (Intellectual Observer, vol. x. p. 461):—

"At 12^h 41^m a dazzling object, two or three times as bright as Venus, passed in a second from midway between the 'pointers' to the nose of the Lesser Bear, leaving a bright streak, divided, like the last, into two parts; but the first part in this case remained visible the longest. The end-half afforded a decided spectrum, appearing as a single bright band in the spectroscope no broader than if looked at through an ordinary piece of glass . . . . .

"The number of streaks now visible in the sky gave another opportunity for using the spectroscope.

"1866, Nov. 14th, 12^h 54^m A.M.—Equal to Sirius; from 3 Canis Minoris to β Eridani. Left a streak for five seconds. The streak appeared as an extremely fine line in the spectroscope *.

"A more powerful spectroscope was now employed, consisting of the central portion only of a Herschel-Browning spectroscope, containing two prisms, and producing therefore twice the dispersion of a single prism. My assistant, Mr. Macgregor, looking at the streaks with the unassisted eye, whilst I watched the same streaks in the spectroscope, we each called out 'gone' when the streaks appeared to us to vanish.

* Not the least doubt could be entertained that the light of the streaks in this, and the accompanying instances, was homogeneous; or, at least, quite different in appearance in the prisms from the light of a fixed star.—A. S. H.

"12^h 56^m A.M.—Equal to a first-magnitude star. Left a greenish-blue streak from three to four seconds. We differed in our vanishing moments two-tenths of a scond.

"12^h 57^m A.M.—Equal to a first-magnitude star. Left a greenish-blue streak for from three to four seconds. We differed in our vanishing moments one-tenth of a second.

"1^h 0^m A.M.—Equal to Sirius. Left a greenish-blue streak for four seconds. We spoke together.

"The result shows that some of the streaks were composed of monochromatic light, altogether undimmed by its passage through the prisms."

Mr. Browning observed the spectra of several meteors in the meteor-spectroscope, from the observatory of Mr. Barnes at Upper Holloway, London, between 9^h 30^m P.M., and 4^h A.M. on the morning of the 14th of November 1866.

The spectra which he obtained were of four kinds:—

"1. Continuous spectra *of the nuclei*, in which the whole of the colours of the solar spectrum were visible, except violet. In even the most uniform of these, I am inclined to think that the yellow was strongly predominant*.

"2. Those which gave a bright orange-yellow line of light, or only a faint continuous spectrum in addition to this yellow line†.

"3. Spectra consisting, apparently, of only a single line of green light, of nearly the same colour as that shown by thallium.

"Of this kind I only obtained the spectra of two meteors. In one of these I thought that I detected, in addition, a very faint continuous spectrum, nearly obscured by the brilliancy of the green line.

"4. The spectra *of the trains*.

"The light from green trains appeared continuous in the prisms.

"Those which were of a blue colour appeared as a [(?)faint] line of lavender colour, with a still fainter trace of a continuous spectrum. In some few instances [*i. e.*(?) of the lavender line] no continuous spectrum could be detected."

Mr. Greg obtained the following observations with the meteor-spectroscope at Manchester.

"The spectra of the nuclei of the three large ones which I observed, much resembled in size and gorgeous effect that of the crescent moon, which I looked at in the meteor-spectroscope on the following evening. As I did not see the meteors with direct vision, I cannot say how large they appeared naturally.

"Their spectra all consisted of crimson, green, and blue. The spectra of two of them were a little less well marked at the outer edges, and between the colours, than the spectrum of the third, in which the demarcation between the red, green, and blue, as well as the definition at the outer edges of the spectrum, was perfect. In one of them there seemed to be pretty numerous darker lines across the spectrum in a vertical direction; and at the instant of disappearance I saw, or thought that I saw, an orange line, or band between

* When a star of small magnitude is looked at through the meteor-spectroscope, its light is either completely washed out, and invisible, or a line of faint and apparently colourless light marks its place. The length of this line of light, up to the cases of those stars in which it can no longer be discerned, continues to be about half a degree. *There exists no tendency in the yellow rays of the stellar spectra to remain outstanding*, when fixed stars of very feeble light are examined in the meteor-spectroscope.—A. S. H.

† Similar spectra *of the nuclei* of meteors to these are described in the last Report for 1866, p. 144.

the green and red, suddenly appear and disappear. It was not straight across the spectrum, but deflected, or jagged, thus 

"The spectrum of the trains was extremely feeble. I could hardly say that there was any colour."

Characteristic Appearances.

At Greenwich, on one or two occasions during the display, meteors were observed to have a double out-burst, the principal meteors passing on at the head of the stream of light, the secondary nucleus remaining in the luminous track. The accompanying is a sketch of one of these remarkable objects, supplied by Mr. Dunkin, of the Royal Observatory, in a drawing illustrating the general appearance of the shower. (Leisure Hour, Jan. 5th, 1867.)

A *triple meteor*, each part being as bright as Venus, is described by Mr. G. Forbes as having been seen by him at St. Andrews (Philosophical Magazine, S. 4. vol. xxxiii. p. 83) at 12^h 41^m A.M., which left a streak visible for eight minutes. At Glasgow attention was drawn to the meteor by the bright light in the first half of its course. At this part a streak remained visible for nine minutes, and collected itself into an oval form, while the portion of the streak in the last half of the meteor's course, in which a good view of the meteor was obtained at Glasgow, remained straight, and faded away in about 30 seconds. The appearance of the meteor in the latter portion of its path, at Glasgow, was that of a single pear-shaped nucleus about as bright as Venus, drawing a bright train of light, like that left by other bright meteors of the shower.

A remarkable double meteor, equally curious, was observed by M. J. J. Silbermann of the Collége de France, at Paris, during the progress of the shower. This meteor passed slowly from Leo to the square of Ursa Major, and onwards towards the west horizon, leaving no train. It consisted of two brilliant round white nuclei, each about as bright as Jupiter, and 15′ apart, which oscillated to and fro, and before and behind each other, exactly as if performing perfect revolutions in a circle round each other, in a plane perpendicular to the visual line,—one revolution in every second of time. The whole duration was 8 or 10 seconds, and both meteors disappeared together. (Le Moniteur, Nov. 20th, 1867.)

At *Hawkhurst.*—"At 12^h 6^m A.M., two pear-shaped meteors, both brighter than Venus, changing from yellow into orange, pursued one another in almost identically the same course, at an apparent distance of about three moon's diameters between them, both expanding together, and both leaving trains.

"Another red meteor, about the same time, which grew to be as bright and round as Sirius, was distinctly observed by all to make two darts or shots in its flight.

"At 12^h 39^m 30^s A.M., two fine meteors, with well-defined disks and elon-

gated behind, moved as if *in a leash* between the two last stars of Ursa's tail."

At *Beeston.*—Mr. Lowe noticed that "in numbers of instances, when meteors crossed the same portion of the heavens, the paths of each were of the same length." This may perhaps serve to explain the coursing of meteors side by side, which was frequently observed, for the same length and with the same velocity.

At *Birmingham.*—From Mr. Wood's observations:—"Binary meteors: $0^h\ 21^m$ A.M. Two meteors of green colour, each brighter than first-magnitude stars, shot together from the direction of the radiant-point, appearing at R. A. 147° ($9^h\ 48^m$), N. Decl. 24°, and disappearing, after leaving yellow

Fig. 1.

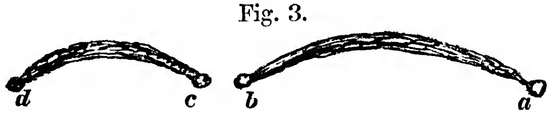
streaks which remained for $2\frac{1}{2}$ seconds, at R.A. 143° ($9^h\ 32^m$), N. Decl. 6°. The distance between them at their first appearance is represented in the figure at *a*, about half a degree; and their distance widened a little towards their disappearance, which took place as shown in the figure at *b*.

Fig. 2.

"$0^h\ 27^m$ A.M. Two white meteors, each as bright as first-magnitude stars, shot together from the direction of η Leonis; appearing at R. A. 150° (10^h), N. Decl. 38°, and disappearing at α Ursæ Majoris, each leaving a greenish streak. The meteors appeared together, with a distance of about 2° between them, as at *a*, and moved with almost perfectly parallel paths side by side, with, however, a considerable widening, until they had, at disappearance, the relative positions at *b* (fig. 2).

"Curved paths: extinctions and rekindling of the meteors, although not registered, were observed. A meteor, which was observed to pass through Ursa Major, made its appearance as at

Fig. 3.



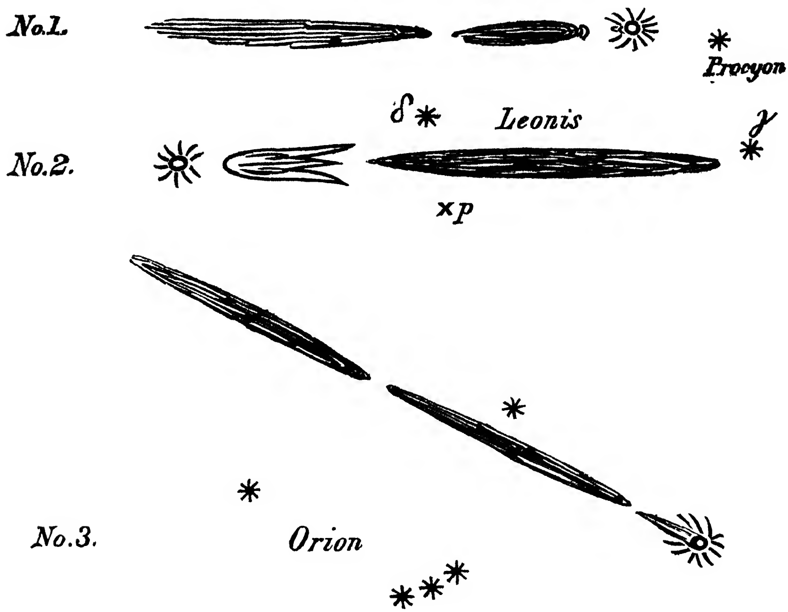
a (fig. 3), described a phosphorescent curve *a*, *b*, and disappeared at *b*, then reappeared at *c*, described another short curve *c*, *d*, and finally disappeared at *d*."

Intermittent Light.—Mr. C. Grover, at Chesham, Bucks, gives the following instances of large meteors, which disappeared for an instant, and afterwards reappeared in continuation of their former course. The two first are also noted (by coloured drawings in the original report) as examples of the most brilliant coloration observed in the shower, during the morning of the 14th of November.

No. 1 was a remarkably luminous meteor, which appeared at about $12^h\ 30^m$, and exhibited a partial extinction of light upon its course.

No. 2 (recorded in the Catalogue), at $1^h\ 10^m$ A.M., also showed a single intermittence of its light. It was the largest and brightest of all the meteors recorded at Chesham.

No. 3 also presented a distinct interruption of its light. It was especially brilliant, shedding quite a glare of light on surrounding objects.



General Appearances of the Shower.

Mr. Wood thus describes the general characteristics of the meteors :—

"Unlike those of any other display, they never burst or threw off sparks, but either burnt gradually away, or wasted away in forming the streak. This meteoric shower is further distinguished by striking uniformity in colour, size, and greater duration, both of the meteor and of the streak, than in other showers. The colour may be said to be pale green, the proportion between this and the red being about 4 to 1. The average size was nearly that of Mars, then shining, which many of the meteors resembled. A small proportion only were equal to Jupiter; and I saw only one that somewhat exceeded Venus at its greatest brilliancy. Another peculiar feature of the meteors was great accuracy of radiation.

Fig. 4.

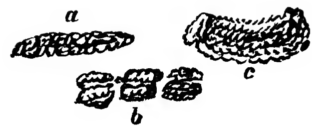
Fig. 5.

"Phenomena at the radiant-point.—Figure 4 represents one of the blue nebulous patches deprived of the true meteoric lustre, which appeared from time to time close to the radiant-point. In 3 or 4 seconds they would rapidly fade and expand to double their former diameter (as fig. 5). One such object appeared at 12^{h} 45^{m} A.M. It resembled a varying star, increasing from the first magnitude to the brilliancy of Venus in about 4 seconds, exactly at the radiant-point, in R. A. 148°, N. Decl. 25°.

"Meteor-streaks within a circle of 4° radius round this point were *never preceded nor followed* by any nucleus or true meteor, but were *suddenly formed* without any apparent cause, and appeared more compact and brighter than

those observed elsewhere, but always rippled and waved, and varying from one to two lunar diameters in length.

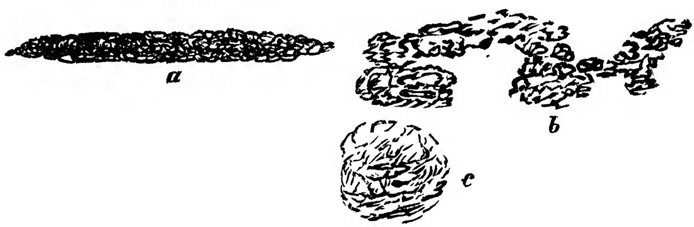
Fig. 6.



"In fig. 6, *a*, *b*, *c* represent three successive stages of change of such a streak, from its first appearance, *a*, when it shortly began to separate and expand as at *b*, and finally to curl up as at *c*, and dissolve like a trail of smoke.

"These small trains frequently branched out from the radiant-point like the spokes of a wheel, three or four at a time. A group of four radial streaks, 2° or 3° in length, was thus suddenly formed round the radiant at $12^h\ 36^m\ 15^s$ A.M., indicating its place very exactly, as already given.

Fig. 7.

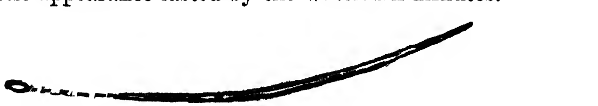


"At $2^h\ 16^m$, a green meteor, brighter than Venus, moved from the radiant-point to R. A. 135° (9^h), N. Decl. 20°, leaving a broad green streak 4′ or 5′ in width upon its course (fig. 7, *a*). This meteor was the brightest, and its streak was the broadest and the most enduring seen. The latter remained as a bright green rippled and waved bar of light for six seconds before either fading, curling up, or dissolving away. It then gradually, in the space of about two minutes, assumed the form of fig. 7, *b*.

"Between one and two minutes after its first appearance, I perceived the spot *c* (fig. 7), resembling in size and appearance the *Præsepe Cancri*, a very little in advance of the spot where the meteor disappeared. Whether it was formed there by drifting from *b*, or if it was independently formed by the meteor, I cannot say, but I incline to the latter opinion."

The streaks, when first deposited, were remarkably straight, and fine, bright, lance-like lines. They then, as described by Mr. T. Morris at Manchester, "in many instances appeared to swell in the centre of their length —the point of greatest ignition probably—and taper towards the extremity, forming an approach to a double cone."

In a letter to a Member of the Committee, describing some of the phenomena of the shower as it appeared at Hawkhurst, Sir John Herschel remarks:—"In a *great many* instances (indeed most commonly) the *head* SHOT AHEAD of the train, as a star or planet of a very high red colour. All the trains were sparkling like star-dust, but in two or three cases there was a remainder of cometic phosphorescent light, very persistent. In one which exploded with a flash close to α, β, γ Arietis [see Catalogue, $1^h\ 12^m\ 30^s$ A.M.], this cometic appearance lasted by the watch six minutes."



In illustration of this peculiarity the following was observed at Hawk-

hurst. "About 11^h 30^m, a dull yellow meteor, which grew to a round disk, moved on a curved course (see fig.), nearly horizontally from Ursa Minor to a point due west, leaving a slight train. The nucleus lasted three seconds, *and continued after the train had faded away.*"

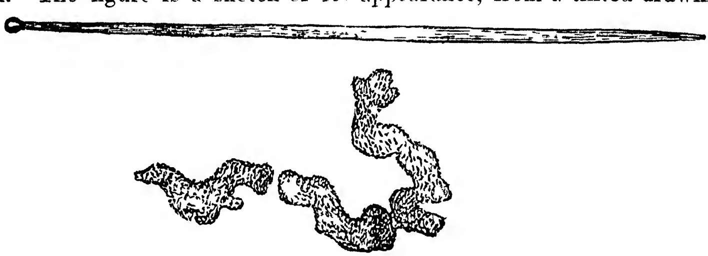
Mr. Greg observed, at Manchester :—"Nearly all the meteors showed either as simply phosphorescent or lance-like lines, or began as such. But in the case of the larger ones, with disks of 2′ or upwards, the nuclei seemed finally to emerge from, or to shake off, or lose the phosphorescence, for the space of a few degrees and then vanish."

Mr. C. Grover, in his observations of the November meteoric shower at Chesham, Bucks, reports that, "in nearly every instance, the head ceased to emit a train before it vanished, *consequently the head was clearly parted from the train just before vanishing.*"

The same was noticed by M. Goulier in the 'Comptes Rendus' for December 1866, whose observation of the position of the radiant-point at Metz (in the Moselle) is cited above. "A remarkable peculiarity of the meteors was, that the streaks were shorter than the entire length of their course, the nucleus shooting ahead of the train for some space without emitting the phosphorescent light of the streak."

Contortions of the Trains.—The large meteor recorded by Mr. H. S. Heinecken at Sidmouth, at 1^h 8^m 9^s (see Catalogue), left a train which was very conspicuous for six minutes, and remained visible for at least ten minutes.

At first the train was straight, but when the terminations faded, the central portion became curved, and folded back in a serpent-like form upon itself. The figure is a sketch of its appearance, from a tinted drawing by



Mr. Hutchinson. It afterwards became brilliantly nebulous, more circular and compact, and retrograded slowly along the course of the meteor towards the east.

In the 'Monthly Notices' of the Royal Astronomical Society (vol. xxvii. p. 53), Mr. G. Venables draws attention to the fact that, in some instances of trains which continued for a length of time, the deflection which occurred was "not curved but rigid, like a stiff stick broken in the middle."

Telescopic Observations of the Meteors.

At *Wisbeach*, Cambridgeshire.—Mr. S. H. Miller reports :—"After the dis-

appearance of the head, the trains contracted and curled up, and I was able

to use the telescope with a power of 45. The trains then looked much like some Nebulæ, and I saw these forms (see figures)."

At Bathwick Hill, Bath, Mr. W. Dobson reports:—"I observed the trains of several with an achromatic telescope (Cooke's 4-inch aperture, power 40). They mostly disappeared rapidly, except one large one, about $1^h\ 50^m$ A.M., low in the west, the train of which remained visible in the telescope for nine minutes. It appeared like a long wisp of luminous vapour or smoke, bending and changing its form, growing broader and fainter, and drifting slowly down the wind. While observing it another smaller one crossed the field of the telescope, but its train disappeared in a few seconds."

Mr. T. Crumplen made many telescopic observations, leading in some cases to good results, both of the nuclei and of the trains of the meteors, from Primrose Hill.

"The instrument used was by Dollond, of $1\frac{5}{8}$-inch clear aperture, about 22 inches focal length, and power of 30. I took care to focus it on a fixed star, so that no doubt could arise as to the value of the observations made, and these, so far as practicable, were confirmed by my assistant, who is also accustomed to use the telescope for celestial objects.

"I saw many meteor-trains by this means, but in most cases they faded too rapidly for good observations. Eight, however, were examined with great success.

"One of these, at $1^h\ 7^m$, was visible 10 full minutes. When first seen, immediately after the meteor disappeared, it looked like a long piece of riband in constant motion, and waved throughout its entire length. This band was then nearly 5′ in width, and appeared streaky or mottled, *as if made up of an immense number of interlaced filaments.*

"It changed shape during the time that I observed it, gradually becoming more nebulous, and at last it was almost a circular patch, somewhat elongated towards the west. When in this state it passed over a tolerably bright telescopic star. I could see the star approaching, and I noticed a decided difference in the brilliancy and appearance of this star when immersed in the meteor-train. It was undoubtedly refracted*. This meteor disappeared some 5° below α Tauri, and the train drifted as much more towards the west-north-west horizon before it finally disappeared.

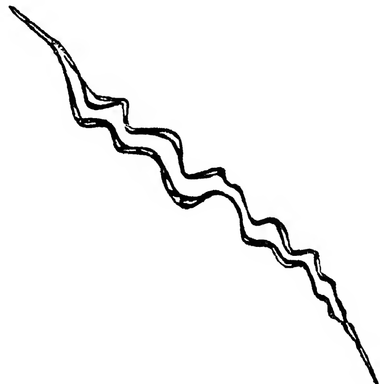
"Besides this train, I had telescopic views of seven others, which underwent similar contortions. In several cases the trains bent upwards, becoming shaped like the crescent moon †, the horns always directed to the zenith. *The filaments* in the telescope almost always reminded me of the particles of fibre which fly from the sudden lash of a whip.

"It was extremely difficult to get a view of a nucleus. In two instances I caught them passing the field, but in flight too transient to permit me to speak of their appearance in positive terms. They resembled a solid body imbedded in a nebulous haze; but although I have their appearance well in my mind, I forbear to say anything open to question."

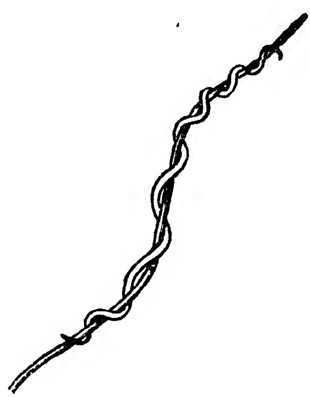
* As the effect of refraction would make the star hang upon the edge of the cloud, as is sometimes believed to be the case from a similar cause in the occultation of stars by the moon, such an effect may have been, hitherto, overlooked. That the star's appearance was affected by partial absorption, or obscuration of its light, is an alteration more easy, in general, to be explained by a haze, or misty vapour suspended in the cloud.

† This appearance was sometimes observed with the naked eye. An observer at Mentone, Mr. Moggridge, in a letter to a Member of the Committee, states that they heralded great outbreaks of the meteoric shower immediately following their appearance, and terms them "lunettes."

At *Wimbledon*, Mr. F. C. Penrose reports:—"At about 2^h 30^m A.M. we took our stand at the telescope, without, however, making any particular observations until 3^h 6^m A.M., when a bright short streak was observed, in R. A. 13^h 12^m, N. Decl. 37°. It was of bluish-silvery colour, and resembled a riband, as shown in the figure; but there were probably many more 'kinks' in it than here shown. It remained visible in the telescope several minutes, and finally before vanishing, separated into two parts."



In illustration of the many "kinks" observed with the telescope in the streak of this meteor, Mr. Penrose gives the annexed representation of the tendril of a climbing plant, twined towards the right, or towards the left, round a slender stem. Eddies and currents of air along the course of the meteor's flight, of the nature of smoke-rings, propagated obliquely towards the right or left, might very possibly conduce to the twisted and knotted appearance of the streak, most commonly observed with the telescope.



"About this time H. observed a small meteor in the telescope passing over the field of view, between θ and ι (the sword stars) of Orion; and F. soon after saw one pass the field of view near the Præsepe of Cancer. Neither of them showed any remarkable feature, and they left no train. F. saw that which passed the Sword of Orion with the naked eye. It was one of the average smaller meteors. It appeared in the telescope exactly like a star of the sixth magnitude.

"At 3^h 25^m 50^s, we saw in the telescope, at a point about R. A. 15^h 20^m, N. Decl. 55°, the streak of a meteor, narrower and brighter than that before described, but otherwise similar in structure to it, full of kinks and bends, but this being of greater length than the former, there were more of them."

General accounts of observations of the shower were also received from Mr. W. T. Redford, Sidmouth; Mr. H. Player, Totnes, Devonshire; Mr. E. H. Rodd, Penzance; Mr. Clarke Richardson, Swansea; and Mr. G. Iliff, at Sunderland.

Geographical Limits of the Shower.—The brightest portion of the meteoric shower, on the night of the 13th–14th of November 1866, was visible as far eastward as Kishnaghur (lat. 23° 24′ N., long. 83° 37′ E.), about sixty miles due north of Calcutta, and as far westwards as a point in the Atlantic Ocean, near the Azores, in lat. 39° 56′ N., long. 32° 20′ W., or over a zone of at least 115° 57′ of longitude.

It was observed at Aberdeen, in Scotland (lat. 57° 9′ 51″ N.), and at the Cape of Good Hope Observatory (lat. 33° 56′ 3″ S.), or over an extent of 91° in latitude.

The boundaries of this area nearly coincide with that of the star-shower seen on the 13th of November 1832, which was succeeded in the following year by the well-known great November shower in America, observed by Twining and Olmsted, on the morning of the 13th of November 1833, by a recurrence of which in the present year (1867), the shower now described would thus be followed by a fitting sequel.

(4.) The December meteoric shower, in 1866.

At *Kishnaghur*, Lower Bengal, India.—Extract of a letter from Mr. W. Masters to Sir J. F. W. Herschel, Bart.—"Since the morning of the 14th of November, diverging meteors were not seen or detected on any of the periodic dates, except the 12th of December. I observed them at 2^h 30^m A.M. of this date. They might have come on at an earlier hour, and they appeared to have passed off by 3^h A.M. They shot divergingly, and with great rapidity, from a point about 29° or 30° of North Declination, and 136° of Right Ascension. They darted out at the rate of about three per minute, were small, described short and thin arcs of light, and left no traces. Some showed themselves only as moderate flashes of light, about 40° or 50° from this point, without any visible arc of light or course.

"A bright meteor with a long train shot across the area of divergence from nearly due south to north, or from Alphard (α) in Hydra, to θ in Ursa Major.—Kishnaghur College, 20th December, 1866."

At *Birmingham*, Mr. Wood kept a strict watch for meteors on the nights of the 12th and 13th of December. "On the night of the 11th, the sky at Birmingham was overcast all night. Towards 11^h P.M., on the night of the 12th, meteors were very frequent, about one per minute in one half of the sky, the other half of the sky being overcast. The sky then became completely overcast, and remained so until shortly after midnight, when it became partly clear, and the frequency of the meteors was found to have greatly decreased. From 12^h 53^m A.M. until 1^h 15^m A.M., with two-thirds to a quarter of the sky quite clear, *none* were seen. The maximum of the shower probably occurred between eleven and twelve o'clock, beginning at 10^h 30^m P.M. on the 12th, and ending at 1^h A.M. on the 13th. The radiant-point was between θ and α Geminorum. The meteors were blue and white, of momentary duration, and the majority of them without trains. On the night of the 13th the sky was clear, but no meteors were seen in twenty minutes from 9^h 30^m P.M. to 9^h 50^m P.M. A display of aurora borealis appeared in the N.N.W., with streamers radiating from a point below the horizon, moving from west to east, and 120° or more in length."

At *Milbrook*, *Tuam*, in Ireland, the sky began to clear on the night of the 12th, at 9 o'clock. From that time until 1^h 25^m A.M. on the 13th, Mr. Birmingham counted 260 meteors, of which number 20 only were unconformable. Although nine meteors, between 9^h 15^m P.M. and 9^h 30^m P.M., were shown by alignments to radiate from within a circle about 3° in diameter, with its centre in R. A. 107°, N. Decl. 19°, yet a meteor, nearly stationary at the intersection of lines joining β and ϵ, δ and θ Geminorum, appeared to indicate a somewhat higher radiant. In comparison with the November shower, the aspect of the meteors might be described as *cindery*, with, however, a few notable exceptions. They were mostly of a bluish-white colour, many trainless, but in general leaving a faint train of the same colour as the nucleus. One meteor, that was brighter than Sirius, showed a serpentine course. There was no well-marked time of maximum, but there seemed to be alternate periods of repose and activity. At 3^h 8^m an immense fire-

ball flashed through a misty break of the clouds in Leo, leaving all again in darkness" †.

(5.) The January meteoric shower, in 1867.

Heavy snow, and the overcast state of the sky in England on the night of the 1st and morning of the 2nd of January 1867, prevented observations of luminous meteors. On the evening of the 2nd of January, about $9^h\,30^m$ P.M., when the sky was comparatively clear, Mr. Crumplen watched for meteors for a few minutes, in London, and saw none.

(6.) The April meteoric shower, in 1867.

On the nights of the 19th and 20th of April 1867, the sky was overcast, with constant rain, at Glasgow. No reports of the reappearance of the April meteoric shower, in 1867 have been received from other places.

(7.) The August meteors, in 1867.

At *Birmingham*, Mr. Wood reports a very fine sky on the nights of the 9th, 11th, and 12th. On the night of the 10th the sky was clear over head until $1^h\,30^m$ A.M. on the morning of the 11th.

From 9^h P.M. to $11^h\,32^m$ P.M. on the 9th, only two meteors were observed in one hour and a half. Their number then increased, and the paths of 18 meteors were recorded in two hours. There was an equal scarcity of meteors on the night of the 10th; when, in one hour, from 9^h P.M. to 10^h P.M. no meteors were observed. The interval of half an hour, from $12^h\,16^m$ to $12^h\,45^m$ A.M. on the morning of the 11th, also presented a total absence of meteors. Five meteors were then observed in 15 minutes, and the sky afterwards became overcast. On the nights of the 11th and 12th the rate of apparition was respectively 3 and 2 meteors per hour. On the morning of the 11th it was as high as 7, and on the morning of the 10th as high as 14 per hour.

Date and hour of observation .	8th P.M.	9th ($11^h\,30^m$ P.M. to midn.).	10th A.M.	10th (11^h P.M. to midn.)	11th A.M.	11th P.M.	12th P.M.
Average number of meteors per hour ..	6	10	14	7	7	3	2

Moon nearly full. One observer.

The frequency, under similar cicumstances, is little more than half as great as that observed by Mr. Wood in the previous August epoch of 1866.

A wide radiant area, extending from γ Persei to C, c, and l Camelopardi, as distinct radiants, is assigned by Mr. Wood to the recorded paths; with a tendency to radiate chiefly from a principal radiant-point at ϵ Cassiopeiæ.

The relative proportions of meteors of different magnitudes and colours were about as follows:—

Above 1st mag*.	= 1st-mag*.	= 2nd-mag*.	= 3rd-mag*.	Blue.	Yellow or orange.	White.
$\frac{1}{5}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$	$\frac{5}{8}$	$\frac{3}{10}$	$\frac{1}{16}$

At *Manchester*.—Mr. Greg reports that the meteors appeared rather to

† Monthly Notices of the Royal Astronomical Society, vol. xxvii. p. 205.

emanate from a linear radiant region, extending from α Persei to γ Cassiopeiæ, than from a single point (which is usually attributed to the shower) near the sword-handle of Perseus.

In *America*.—The Committee is indebted to Mr. Marsh for the following communication of a register of shooting-stars observed at Germantown, near Philadelphia, U. S. A., on the mornings of the 10th and 11th of August 1867, by three observers. Each person observed independently of the others, and their attention was mainly directed to the north-east.

Philadelphia mean time of observation, 1867, August 10th A.M.	Number of meteors observed							
	By B. V. Marsh.				By C. H. Darlington.			
	Conformable.	Non-conformable.	Total.	Estimated bright enough to be seen in full moonlight.	Conformable.	Non-conformable.	Total.	Estimated bright enough to be seen in full moonlight.
h m h m								
From 1 3 to 1 45 A.M.	10	7	17	3	10	4	14	2
„ 1 45 „ 2 0 „	6	4	10	3	6	1	7	3
„ 2 0 „ 2 15 „	3	0	3	0	3	1	4	0
„ 2 15 „ 2 30 „	3	2	5	1	1	1	2	1
Total numbers in one hour and forty-five minutes .	22	13	35	7	20	7	27	6

Those originating near the radiant indicated the usual point in Perseus; but some of the more distant ones seemed to come from the direction of Cassiopeia.

Successive intervals of fifteen minutes, 1867, Aug. 11th A.M.	Number of meteors observed					
	By B. V. Marsh.			By R. M. Gummere.		
Philadelphia mean time	Conformable	Nonconformable.	Total.	Conformable.	Nonconformable	Total.
h m h m						
From 12 0 to 12 15 A.M.	14	1	15			22
„ 0 15 „ 0 30 „	15	3	18			19
„ 0 30 „ 0 45 „	8	2	10	6	2	8
„ 0 45 „ 1 0 „	13	3	16	24	3	27
„ 1 0 „ 1 15 „	14	4	18	13	3	16
„ 1 15 „ 1 30 „	8	5	13	13	4	17
„ 1 30 „ 1 45 „	10	3	13	15	3	18
„ 1 45 „ 2 0 „	11	3	14	19	2	21
„ 2 0 „ 2 15 „	10	2	12	16	0	16
Total numbers in two hours and fifteen minutes	103	26	129			164

The average magnitude was decidedly below that of previous years. Only a few left persistent trains, and there were none of very great splendour. The weather was clear, and circumstances altogether favourable.

At a somewhat later hour than the last of the above observations, the August meteoric shower appears to have reached its maximum in America.

New York Herald, August 12th.—"Poughkeepsie, August, 11th, 1867:—Shortly after one o'clock this morning an entirely clear sky was visible.... From one till two A.M. over seventy meteors were counted, and from that time till half-past three A.M. they increased in number so fast that they could not be counted. Three of them were of great brilliancy. By four o'clock A.M. the unusual exhibition had entirely ceased."

The rarest displays of shower-meteors are comparatively brief in their duration, and Mr. Marsh points out "that observations extending over several days, and VARIOUSLY SITUATED IN LONGITUDE, are needed, in order to show the earth's progress through the group, and to determine the exact time of central passage."

V. Papers relating to Observations of Luminous Meteors.

1. Professor Newton, on "The Relative Number of Shooting-stars seen in a given Period by different numbers of Observers." (American Journal of Science, 2nd ser. vol. xli. p. 192.)

The results of this careful series of observations made at Newhaven, Connecticut, on the morning of the 15th of November 1865, may be referred to as a common standard for determining the rate of apparition of meteors in cases where several observers combine together to register their numbers.

During the three hours, from midnight until three o'clock A.M., on the morning of the 15th of November, twelve observers at Newhaven were so arranged that two looked to the zenith, and the remaining ten divided the points of the compass equally between them. As each observer saw a meteor he called his name, which was entered by an initial letter in the register. By three o'clock 186 meteors were counted.

The average number seen by each person was 38·75. Hence the proportion—

No. seen by one observer : No. seen by twelve : : 38·75 : 186......(1)

The average number seen by two persons looking towards opposite points of the compass (taking all the pairs of such observers) was 75·4 : and hence

No. seen by two observers : No. seen by twelve : : 75·4 : 186......(2)

The average number seen by three observers looking nearly symmetrically to different points of the compass (taking all the combinations of such observers) was 99·7. Whence

No. seen by three observers : No. seen by twelve : : 99·7 : 186......(3)

Proceeding thus with all the symmetrical combinations of four, five, six, or more observers, and comparing the results with the similar results obtained by a party of six observers on the night of the 15th of August 1865, the numbers seen by more or less numerous observers are shown in the following Table, which also contains the relative numbers seen by different parties of observers, in the time that four observers would take to count 100.

No. of observers.	Average No. of meteors seen during the watch.		Average No. of meteors seen while four observers would count 100.	
	Aug. 15th, 1865.	Nov. 15th, 1865.	Aug. 15th, 1865.	Nov. 15th, 1865.
1	49·44	38·75	35·9	32 5
2	89·65	75·40	65·1	63·3
3	117 88	99·70	85·6	83·6
4	137·71	119·20	100·0	100·0
5	156·44	131·86	113·6	110 6
6	172·00	143 00	124·9	120·0
7	......	152 86	...	128 2
8	......	160·67	......	134·8
9	......	166·75	.. ..	139 9
10	......	173·50	......	145 1
11	......	179·83	..	150·9
12	......	186·00	...	156·0

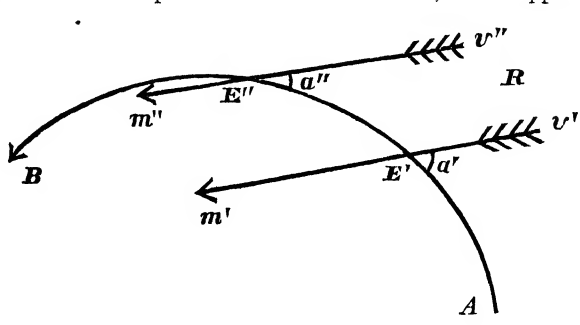
The last column of the Table shows that a single observer would not count more than a fifth part, nor four observers more than two-thirds of the meteors visible in a given period.

2. Mr. R. P. Greg "On Meteoric Showers and their Radiant-points. (Bulletins de l'Académie Royale de Belgique, 2nd ser. vol. xxiii. No. 2, 1867.)

"The meteoric shower of the 2nd of January 1867, was far less copious than it appeared on the same date in 1863 and 1864. There is not impossibly a period of five years in its return, and a seven-year period in the returns of the shower-meteors of the 5th–15th of December.

"The linear or oval extension of the radiant region in the case of fifteen or twenty meteoric showers, some them of long duration (six or eight weeks), appears to arise from the change of the angle of intersection of the orbits of the meteoric bodies with the earth's orbit. In the course of two months (a sixth part of the whole circumference) the angle of intersection, at the points where the earth enters and leaves the meteoric group, should undergo a very appreciable alteration. In cases of very long duration, it is probable that the orbits of the meteoric bodies nearly coincide with a part of the earth's orbit, and that the meteors of such a group move for some time nearly in the same, or in an opposite direction to the earth's path.

"Suppose A B to be a portion of the earth's orbit, R the apparent place of



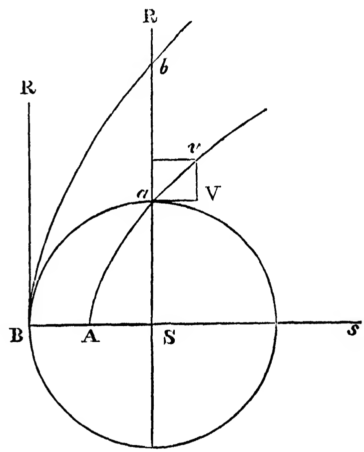
the radiant region, E', E'' two positions of the earth at entering and leaving the meteoric group, embracing between them an interval of two months,

$v' m'$, $v'' m''$ the apparent directions of two meteors directed from the radiant R. Then the angle a' is evidently greater than a''.

"As far as I have been able to examine the question, the arc subtended by the difference of the angles a', a'' may be more or less exactly measured by comparing together the lengths of the major and minor axes of the radiant region in those cases where it appears to have an elongated form. Projected and measured upon a map of the stars, this arc occasionally amounts to 10°, or 15°, independently of 5° allowed for errors of observation, and for other sources of inaccuracy."

By the "arc subtended by the difference of the angles a', a''," the difference from parallelism between the lines $v' m'$, $v'' m''$ in the above paper is perhaps intended to be signified; and this may amount occasionally to 15°. It is plain, however, that the real difficulty connected with the long endurance of particular radiant-points in a nearly fixed position is, to explain why the elongation of the radiant region, or the difference from parallelism actually observed, *does not, in general*, amount to a quantity nearly as large as the difference between the angles a', a''.

Thus, supposing A a, B b to be the inner and outer limits of a current of meteoric bodies moving in parabolic orbits round the sun, S, in the same plane with the earth's orbit, a B, and having the common axis B S s; S a, perpendicular to B S, the earth's distance from the sun when it encounters the inner limit of the stream, three months before the time when it arrives at B. The absolute velocity of the meteors where they encounter the earth is everywhere represented by the diagonal of a square, as a v, whose side a V represents the velocity of the earth in its nearly circular orbit. Now as the directions of the circle and parabola at a are, respectively, in the side a V and diagonal a v of the same square, the relative velocity of the meteors at a, with respect to the earth, is in the direction v V, parallel to a S; and this is also the direction of the relative velocity, with respect to the earth, of the meteors which overtake the earth at B. The radiant-point of the meteors at a, B would, in such a case, therefore have a nearly invariable direction, or apparent position in the sky, R R; and in the intermediate interval of three months, during which the shower continues, it would only undergo very small changes of its place.



Catalogue of *Luminous Meteors and Aërolites.* *By* R. P. GREG. *Supplement No.* II. (*continued from* 1860, *Brit. Assoc. Report*).

Year.	Day of month.	Locality.	Size or weight.	Direction.	Duration; rate; hour.	Remarks, &c.
1034.*						Meteor and detonation; not a stonefall. Cat. No. 1.
1510.		Padua				See Cat. No. 1. } Probably all the same; 1510, September 4th.
1511.	Sept. 4	Crema, N. Italy				
1516.		River Abdua, China				Should be Adda, Italy.
1565.		China				Read 1575, July 3rd. See Cat. No. 1. 1860.
1577.	Oct. 21	Zurich				Fireball (R. Wolf).
1603.	Sept. 30	Ibid				Ditto ditto.
1619.	Oct. 15	Frauenfeld				Ditto ditto.
1627.	Nov. 29	Provence, France	stonefall?			Read 1637. } See Cat. No. 1.
1649.*	May 11	Alsace				Probably aërolitic. } See Cat. No. 1.
1653.	Jan. 15	Erphordia?			10 a.m.	Fireball (Buchner *et seq. sæpe*).
1660	Dec. 21	?				Ditto.
1692.	31	America?				Ditto.
1706.	Oct. 29	England?				Ditto.
1709.	Oct.	Lima S. A.				Ditto.
1719.	Mar 30	Netherlands	large			Ditto (Chladni).
1727.	July 22	Lilaschitz, same as Plescowitz and Liboschitz.				Read 1723, June 23rd. Cat. No. 1.
1723 *		Cornwall, England				Stonefall (not in 1622, as in Cat. No. 1).
1731.	Jan. 10	Halstead, Essex				Detonating meteor; stonefall doubtful. Cat. No. 1.
1736.	Oct 1					An electrical phenomenon; seen at Sheffield. Ditto.
1739 *	Dec. 2	England	=moon			Detonating fireball. Cat. No. 1.
1745.	Oct 13	Boulogne				Read Bologna. } See Cat. No. 1.
1753	Sept 7	Luponas				Not Liponas. } See Cat. No. 1.
,, *	Nov. 4	Bourbon, France				Detonating meteor. Ditto.
1756.	Mar. 3	Zurich				Fireball (R. Wolf).
1758 *	Nov. 26	Edinburgh &c.			9 p.m.	Detonating meteor. Cat. No. 1.
1761.	Feb 7	Dorsetshire	large		8.30 p.m.	Fireball; train lasted 5′ (Phipson).
1763.	Apr. 29	Paris	$\frac{1}{3}$ moon		$2\frac{3}{4}$ a.m.	Ditto; 40 seconds; 12° arc, ⊥ down; tailed like a rocket. See Cat. No. 1.
,,	Oct. 17	Scotland	large	N. to S.	7 p.m.	Ditto; gave light of day.
1766.	Feb. 2	Massachusetts				Ditto.
1768.*	Dec. 23	S. Atlantic		E. to W.	7 a.m.	Aërolitic; cloud and train of fire; after two minutes, two cannon-like reports; the cloud endured some time (Cook's Voyages).
,,	Nov.	Charleston, U. S.	=sun			Fireball.
1769.*	Jan. 12	London			1.30 a.m.	Ditto, followed by a detonation.

1774.	Sept. 30	Pine Isle	....	....	....	Ditto (Forster).
1783.	May 31	Richmond, U. S.	....	....	....	Ditto.
1787.*	Aug. 7	New Hampshire, U. S. A.	....	....	....	A cloud discharged violent detonations. Cat. No, 1.
1788.*	Oct. 17	Connecticut, New York	....	E. to W.	$6\frac{1}{2}$ p.m.	Detonating meteor. Cat. No. 1.
1789.*	Summer.	Worms	....	....	....	Ditto ditto.
1797.*	Jan. 4	Kiew, Russia	....	....	....	Stonefall.
1799.	April 5	Baton Rouge, Miss.	....	....	....	Should be A.D. 1800. Cat. No. 1.
1801.	Jan. 7	Penn., Va., U. S.	....	....	....	Fireball.
1803.	Aug. 7	?	....	....	....	Ditto.
,,	9	?	....	....	....	Ditto.
,,	Sept. 17	Mecklenburg	....	....	....	Ditto.
,,	Oct. 10	?	....	....	....	Ditto.
,,	Nov. 7	?	....	....	....	Ditto.
1805.*	Feb. 17	Sigmaringen, Germany	....	....	....	Detonating fireball.
1808.	? ...	Moradabad, E. Indies	....	....	....	Stonefall. (See Cat. No. 1).
,,	?	Greenland	....	....	....	Fireball, not a stonefall. (Cat. No. 1).
,,	July 17	N. America	....	....	....	Ditto. Cat. No. 1.
1809.	June 17	St Bart	(June 20)?	....	....	Stonefall; same as next in Cat. No. 1.
1810.	Jan. 30	Caswell, N. C.	....	....	....	Stonefall; date omitted in Cat. No. 1.
1811.*?	Nov. 23?	Panganoor, India	....	....	....	A doubtful stonefall; not iron.
1813.	Jan. 27	Brunn	....	....	....	Detonating meteor. See Cat. No. 1.
1815.	....	Darmstadt	Stonefall	....	....	Date unknown; certainly before 1804. Cat. No. 1.
1817.	Feb. 6	England	....	....	....	Fireball.
,,	Jan. 21	Bern	....	....	....	Ditto (Wolf).
,, *?	Dec. 8	Ipswich, England	....	....	....	Equal moon; ? detonation. Cat. No. 1.
1818.*	Jan. 17	Vermont, U. S. A.	....	....	....	Followed by detonation. Ditto.
,,	Aug. 5	Chelmsfort	....	....	....	Read Chelmsford. Ditto.
1819 *	May 2	Aberdeen, Scotland	....	....	$12\frac{1}{2}$ p m	Read May 5. Detonating meteor. Cat. No. 1.
,, *	July 24	Youngstown	....	....	....	Read Ohio, U. S. A. ditto .ditto. Ditto.
1820.	Aug. 6	Ovelgonne, Germany	....	....	....	Read Germany, not Finland. Ditto.
1822.*	Mar. 16	Richmond, New York	....	....	10 p.m.	Read March 9th. Equal $\frac{2}{3}$ moon; detonated. Cat. No. 1.
,, *?	Sept. 10	Carlstadt	....	....	....	Explosion in air; ? aërolitic. Cat. No. 1.
,,	Dec. 10	England	....	....	....	Fireball.
1824.*	Feb. 3	Görlitz (Boulogne?)	....	....	....	Aërolitic meteor. } Cat. No. 1.
1825.	Sept. 15	Owhyhee	....	....	3 p.m.	Read September 27th. }
1826.	Apr. 14	Vermont, U. S.	....	....	....	Fireball.
,,	Mar. 31	New Haven, U. S.	....	....	....	Ditto.
,, *?	May 15	Jamaica	....	....	....	Ditto? a hissing sound, and ferruginous mass found?
,,	19	Echaterinosloff, near Paulograd.	Stonefall	....	....	Perhaps same as Bachmut. Cat. No. 1.
,,	Nov. 6 or 7	Teneriffe	....	....	....	Fireball (Pogg. Annalen).

Catalogue of Luminous Meteors and Aërolites (continued).

Year.	Day of month.	Locality.	Size or weight.	Direction.	Duration; rate; hour.	Remarks, &c.
1827.*	May 22	Somer Co., U. S.	....	....	....	Fireball? stonefall (Wolf).
,,	Aug. 30	Greenwich	....	. . .. .	....	Ditto; see Cat. No. 1.
,, *	30	Kuld-schu, China	... .	. ....	....	Read Kuli-schu, China; a stonefall. Cat. No. 1.
1829.*	Sept. 9	Rásan	....	.. . .	....	Fireball?; stonefall (Kämtz, Pogg. Ann. xxiv. 221.)
,,	26	Bremen, Düsseldorf	. . ....	. . . ..	.. . .	Fireball? (Kamtz, Pogg. Ann. xxiv. 221). Cat. No. 1.
,,	Nov. 19	Prague	. .. ...	E. to W.	10 p m.	Read November 13th. Equal $\frac{2}{3}$ moon; fell in sparks over a field; no detonation. See 'London Review,' 1862, January 2nd. Also Cat. No. 1.
1830.*	May 17	Perth, Scotland	?	. . ...	..... .	Stonefall? (specimen in the British Museum).
1831.*	Jan. 1	Storkyro, Finnland	. .	. . .	. . . .	Fireball and detonation; ditto.
,, *	July 28	Vouillé, France	30 lbs.	....	night	Stonefall; large meteor and three detonations. Cat. No. 1.
,, *?	Aug. 10	West Indies	...	. ..	.	Stonefall (Nouv. Cat., R. Wolf).
1832 or 33.	....	Umballah	Stonefall	. .	..	Probably the same as Agra, 1822, Aug 7th. Cat. No. 1.
1833.	Nov. 12 or 13	New York	. . . ..	. . .	. . .	Read November 13th, 6 A.M. } Cat. No, 1.
,,	Dec. 28	Okaninak	. .	. .. ..	.. ... .	Read Okniny or Okaninah. } Cat. No, 1.
1836.	Feb. 16	Hanover	.. . .	. .	. . .	Fireball.
,, *	Jan. 31	Mascombes, France	. . ..	.. . . .	1 p.m.	Stonefall, accompanied by two detonations.
,, ?*	Dec. 8	Ober-Engadin	.	. . .	8 p.m	Ditto and large meteor (Kesselmeyer).
,,	11	Macao	Stonefall	. .	. . .	November 11th, according to Partsch. Cat. No. 1.
1837.	Jan. 1	Bâslo	. .	. .	.. . .	Fireball.
,,	May 5	East Bridgewater, U. S.	. ...	. . .	. ...	No stones fell, according to Herrick; detonation, even, doubtful. Cat. No. 1.
,,	Nov. 2	New Haven, U. S.	. . . ..	... .	.. ....	Fireball.
,,	16	Penn., U. S.	. .. .	. .	.. ... .	Ditto.
,, *	Dec. 14	Connecticut, U. S. A.		. .	. . .	Detonating fireball. Cat. No. 1.
1838.*	Jan. 29	Kaae, Oude, India	. . .	.. .	.. ..	Stonefall; fell soon after sunset; 17 tollahs weight.
1839.	Feb. 11	New Haven, U. S.	. . . ..	. .	....	Fireball.
1841.*	Mar. 15	Princeton, N. Jersey, U. S.	. .. .		$7\frac{3}{4}$ p.m.	Detonating meteor. Cat. No. 1.
,,	Aug. 9	Lat. S. 33°, and long. E. 64°	. ... .	. ..	....	Fireball.
1842.	Feb. 7	New Haven, U. S.	.. .. .	.. . ..	....	Ditto.
,,	Oct. 5	Kent	.. ....	.. . .	. . ...	Ditto.
,, *	Nov. 13	Pas de Calais, France	.	. . .	. . . .	Ditto; detonation.
1843.	July 26	Manegaon, India	Stonefall	. . .	.. ..	Read Manegaum. Cat. No. 1.
,,	Nov. 20	New Haven	.. .. ..	. . .	....	Fireball.
1844.	Oct. 21	Laysac, France	. ... .	. . .	.. . .	Stonefall at Favars. Cat. No. 1.
,,	June 23	New Haven	. ...	. . .	. .	Fireball.
1846.	May 24	Toulouse	.. .	. . .	. . . .	Ditto (Wolf).
,,	June 7	Darmstadt	.. .	....	.... ..	N.B. Not a stonefall, only a slag. Cat. No. 1.
,,	Sept. 9	Cambridge	....	....	....	Fireball (Wolf).

1846.	Sept. 25	Oxford ...	...	...	...	Fireball (Wolf)
„ *	July 13	Conn., Penn., Va., U. S. ..	$\frac{1}{3}$ moon	...	9.30 p.m.	Ditto; velocity=23 miles per second; detonation 30 miles high; duration 20″ (Sill. Journal, May 1866).
„	Dec. 18	Belfast	=$\frac{1}{2}$ moon	...	...	Fireball.
1847.	May 15	Friburg	...	...	...	Ditto (Wolf).
„	July 25	Florence	> moon	N.	9 p.m.	Ditto; hissing sound heard; reddish (Professor Cocchi).
„	Aug. 15	Teufen	...	...	...	Fireball (Wolf).
1848.	May 20	Castine, Maine, U. S....	$1\frac{1}{2}$ oz.	...	$4\frac{1}{4}$ a.m.	Stonefall (in Cat. No. 1).
„	Dec. 10	Leipzig	...	...	...	Fireball (Wolf).
1850.	Jan. 2	Germany........	...	...	...	Read January 9th; same as the next in the Catalogue No. 1.
„	June 22	Oviedo &c. (Cat. No. 1.) ...	...	...	11 a.m.	Stonefall (Comptes Rendus, vol. xxxi. p. 74).
1852.	Jan. 23	Nellore, Madras	...	...	$4\frac{1}{2}$ p.m.	Stonefall (not Jan. 24th, as in Cat. No. 1),
„	Apr. 12	Berne	...	...	...	Fireball.
„	July 28	Wedde, Holland........	...	...	...	Stonefall, Cat. No. 1; not a genuine fall.
„	Oct. 5	Namur, France	large	...	...	Ditto; streak lasted for a long time (Cosmos, December 1852).
„ *	2	Bustee, Goruckpore, India..	...	...	...	Stonefall.
1854.	Jan. 31	Switzerland	...	...	...	Fireball.
„	Oct. 15	Henworth-on-Tees, Durham, Derby, &c.	...	N.E. to S.W.	9 p.m.	Larger than moon; revolved on axis; great reddish train.
„	Oct. 18	Tabarz, Gotha........	...	...	...	Extremely problematical fall. Cat. No. 1.
1855.*	May 17	Igast, Livland, Russia	...	...	...	Stonefall (specimen in British Museum).
1856.	Mar. 22	Pavia	...	...	...	Fireball.
„ *	Aug. 5	Oviedo, Spain........	...	...	...	Stonefall.
1857.*	26	Stavropol, Caucasus	...	...	5 p.m.	Ditto.
„	May 15	Switzerland	...	...	...	Fireball (Buchner *et seq.*).
„	28	Cheshire	large	S.E. to S.	$11\frac{1}{2}$ p.m.	Ditto.
„	Nov. 11	Michigan, N. A.	...	...	...	Ditto.
„	16	Charleston, U. S.	...	...	...	Ditto.
„ *	26	Konigsberg	...	...	...	Ditto, accompanied by a detonation; stonefall?
1858.	May 19	Kakova	$1\frac{1}{4}$ lb.	...	...	Stonefall (not 29 lbs., as in Cat. No. 1).
„	31	Kent, S. England	$\frac{1}{3}$ moon	...	$11\frac{1}{4}$ p.m.	Fireball; stationary for an instant. Cat. No. 1.
„ *	Aug. 1	Heredia	Stonefall	...	...	Read April 1st. See Cat. No. 1.
„	9	Japan	...	...	11.59 p.m.	Fireball.
„	Sept. 25	Lucknow, India	large as a comet	...	evening;	Very large fireball; pale green; rapid flight.
„ *	Dec. 24	Murcia, Spain........	...	...	...	Stonefall.
1859.*	Feb. 7	Aix, France........	=moon	N.N.W.	...	Fireball; detonation in 4′; 30° arc for path.
„	Apr. 17	Basilicata, S. Italy	...	...	...	Fireball.
„	June 1	Neuchatel	...	...	...	Ditto.

Catalogue of Luminous Meteors and Aërolites (continued).

Year.	Day of month.	Locality.	Size or weight.	Direction.	Duration; rate; hour.	Remarks, &c.
1859.	July 4	London	....	....	....	Fireball.
„ *	31	Montpreis, Styria	5 ozs.	S.	$9\frac{1}{2}$ p.m.	Ditto and stonefall; hissing sound; no detonation; small fireball; three small hot pieces.
„	Aug.	Tours, France	....	....	....	Fireball.
„	20	Amoy, China	$=\frac{1}{2}$ moon	....	6.40 p.m.	Ditto; rose ⊥ up from sea; blue colour.
„ *?	Oct. 4	Florence	large	N.E. to S.W.	8 p.m.	Ditto; detonation doubtful; duration 3″; brilliant.
„	4	Rorka, N. India	....	W.S.W.	....	Ditto; brilliant; path 100° arc.
„	25	Holyhead, Athlone	large	W.N.W.	$7\frac{1}{4}$ p.m.	Ditto; cast shadows; burst over Balbriggan; 140 miles path in 5 seconds; height 70 miles to 20 miles.
„	Nov. 28 or 29	S. W. Bohemia	$\frac{1}{3}$ moon	N.W. to S.E.	$10\frac{1}{4}$ a.m.	Ditto; detonation in $1\frac{1}{4}$. Cat. No. 1.
1860.*	Jan. 16	Kusiali, Kumaon, India	....	....	....	Stonefall.
„	20	Switzerland	....	....	....	Fireball.
„ *	Feb. 2	Alessandria, Piedmont	....	....	$11\frac{3}{4}$ a.m.	Stonefall at St Julien.
„ *?	Mar. 10	Leeds &c.	....	....	....	Detonation heard at Dublin. Cat. No. 1.
„ *	28	Khiragur, Burtpore, India	....	....	....	Stonefall.
„	May 22	Paris	2 > ♃	....	....	Fireball; 70° length of path in 6 seconds.
„ *	June 16	Kusiali, India	....	S.S.E.	5 a.m.	Stonefall; eight or nine explosions heard.
„	July 10	Santander, N. Spain	2 > Venus	....	1″	Fireball.
„	14	Dhurmsala, India	....	....	$2\frac{1}{4}$ p.m.	Stonefall (not 28th July in Cat. No. 1).
„	15	Banff, Scotland	=moon	....	11 p.m.	Fireball.
„	20	All over United States	$\frac{2}{3}$ moon	W. to E.	9.45 p.m.	Ditto; velocity=27 miles a second; 120 to 40 miles high; burst twice; lasted 14 seconds; no noise? (Sill. Journ., September 1860). Cat. No. 1.
„	20 or 21	United States	....	....	....	Read July 20th; same as the preceding: only one meteor. See Cat. No. 1.
„ *?	29	Little Bridy, Dorset	....	....	....	? A dark substance fell with noise and light on reaching ground.
„ *	Aug. 2	United States	=moon	S.E. to N.W.	10 p.m.	Fireball; detonation; 8 seconds: velocity=33 miles a second; path equal 250 miles; height 80 to 30 miles.
„	6	New York, Py., Mass.	brilliant	S.E. to N.W.	7.40 p.m.	Fireball; 11 seconds: velocity=15 miles; path 240 miles; least height 36 miles (see Sill. Journ., May 1862).
„	20	New York	....	....	slow	Fireball; divided into two, each moving parallel.
„	Oct. 13	Baffins Bay	large	....	....	Ditto.
„	20	Greenwich	....	....	5″	Ditto; long streak; bright; 6.45 P.M.
„	Nov. 1	Giessen	....	....	....	Fireball. [Warwick.
„	1	Nottingham, &c.	> Mars	N.N.W.	8.30 p.m.	Ditto; 60 miles in 3 seconds; 80 miles to 30 over

1860. *	Nov. 15	New Jersey	=Sun	....	9½ a.m.	Fireball: great smoke and noise; velocity=27 miles a second.
,,	Dec. 11	Essex	....	....	6.25 p.m.	Ditto; fine meteor; lasted 1 second.
,, *	16	Sienna, Italy	....	....	8 p.m.	Ditto; brilliant; in a few minutes a detonation.
1861.	Jan. 28	Switzerland	....	....	....	Ditto.
,, *	Feb. 14	Tocâne St. Apre, France	¼ oz.	....	6¼ p.m.	Ditto; small fireball and red streak; small stone [fell (see Cosmos).
,,	Mar. 4	Ballarat, Australia	½ moon	S. to N.	9½ a.m.	Fireball; moved slowly; conical; left a train of smoke for 20′; burst.
,,	Apr. 10	Manchester	2′ d.	N E.	....	Fireball; vertical in zenith; bright nucleus, white.
,,	12	Greenwich	2 > ♃	....	1′	Ditto; 30° of path.
,, *	May 12	Butsura, India	32 lbs.	W.N.W.	noon	Stonefall; noise heard over 60 miles; five pieces dovetailed! sp. gr. 3 6.
,, *	14	Canellas, Barcelona	2 lbs. +	....	10 p.m.	Fireball and stonefall: many small stones fell.
,,	June 11	Cracow	....	....	....	Fireball.
,, *	16	Grosjna, Caucasus	....	....	7 p.m.	Stonefall and fireball.
,, *?	July 7	Warrington	large	....	....	Fireball; a noise like thunder heard also.
,,	16	Bristol; Kent, &c.	=moon	W.S.W.	11 30 p.m.	Ditto, 300 miles in 6 seconds; 195 miles over Kent to 65: central over Isle of Wight.
,,	16	Durham; Kent, &c.	large	N.N.W.	10¼ p.m.	Fireball, 12 seconds for 400 miles; 170 miles over Dunkirk to 44 (see Brit. Assoc. Report, 1862).
,,	Aug. 6	Kidderminster	large	N.E. to S.W.	10 p.m.	Fireball; duration 4 seconds.
,,	6	Manchester	4 > ♃	....	18″	Ditto.
,,	10	North America	....	....	....	Ditto.
,,	10	Bilboa, Spain	large	N.E. to S.W.	9 20 p m.	Ditto.
,,	11	Ipswich	....	....	10 20 p m.	Ditto; slow.
,,	21	Greenwich	large	....	8.50 p.m.	Ditto.
,,	Sept. 4	Newfoundland	....	....	....	Ditto.
,,	7	Eure, France	large	W. to E.	11 p.m.	Ditto; light as day.
,,	Oct. 2	Ohio, U. S.	....	....	....	Ditto (Buchner).
,,	3	?	....	....	....	Ditto ditto.
,,	4	Connecticut, U. S.	....	....	....	Fireball; train lasted 2′, and serpentine; brilliant.
,,	5	Berlin	10′ diam.	....	11.29 p.m.	Ditto, with train. From R. A. 58°, Decl. + 20° to R. A. 62°, Decl. + 15°.
,,	10	?	....	....	....	Fireball (Buchner).
,,	Nov. 8	Exeter	....	....	....	Ditto; like a Roman candle; nucleus oval.
,,	12	England	⅔ moon	E. to W.	5.50 p.m.	Ditto; blue and conical; from 95 miles over Cambridge to 20 miles over Lundy Isle, say 360 miles in 7 or 8 seconds.
,,	15	Greenwich	2 > ♃	....	10 15 p.m.	Fireball.
,, *	19	Ipswich; Exeter, &c.	½ moon	N.W.	9.38 p.m.	Ditto; 55 miles over Paris to 30 miles over Norfolk, or 260 miles in 12 seconds; three detonations in 90 seconds; burst into three.

Catalogue of Luminous Meteors and Aërolites (continued).

Year.	Day of month.	Locality.	Size or weight.	Direction.	Duration; rate; hour.	Remarks, &c.
1861.*?	Dec. 2	Magdeburg	... ..	.. ..	. ...	Fireball; detonation doubtful.
" *	3	Germany	$=\frac{1}{2}$ moon	N.N.W. to S.S.E.	7 p.m.	Ditto; burst with noise 60 miles over De Grau; directed from Polaris.
"	7	Westphalia	$\frac{1}{2}$ moon	. ...	10 45 p.m.	Brilliant fireball.
" *	8	North England	=moon	E. to W.	8.16 p m.	Fireball; 110 miles over Hull to 45 miles near Isle of Man, say 160 miles in 7 seconds; detonation heard at Lancaster; cast shadows.
"	9	Glasgow	....	.	5.15 p.m.	Fireball; fine meteor; 9 seconds.
"	11	Leipzig	. . ..	E. to W.	11 p.m.	Ditto (Buchner).
"	14	East Germany	.. . . .	N.W. to S E.	5 p m.	Fireball; very brilliant; finished with a fire-shower
"	17, 25, 30	United States	.. . .	. .	. . .	Ditto (Sill. Journal).
1862.	Jan. 3	New York	$\frac{1}{3}$ moon	E. to W.	7 a.m.	Ditto; left a short train.
"	9	Saxony	. . .	S. to N.	5p.m; 10″.	Greenish blue, brilliant (Buchner).
"	Feb. 2	Lancashire; Notts; Eastbourne; N. Wales.	=moon	S. to N.; M 3 radiant.	8.20 p m.	Fireball, 236 miles in 6 seconds; 190 miles over Lyme Regis to 15 miles over Derbyshire. Point of first appearance near α Taurus; true course W. to E. of the meridian: at 30 miles would equal full moon; train 30″.
"	3	Glasgow. &c.	$\frac{1}{5}$ moon	. . ...	9 p.m.	Fireball; lasted 30″; bolide not trained; white.
"	7	Moravia	.	. . .	5 p m.	Ditto (Buchner).
"	23	Liverpool; Somerset, &c. ...	$\frac{1}{2}$ moon	S.W.	9.25 p.m	Fireball; 40 miles over Stockport to 20 miles over Aberystwith.
"	24	Braunschweitz	. . . .	W. to E.	. . .	Fireball (Buchner).
"	Mar. 3	Weston-super-Mare	$\frac{1}{8}$ moon	⊥ down	9.30 p m.	Ditto; $2\frac{1}{2}$ seconds; slow; reddish.
"	5	Austria	.. ..	.. ..	6 30 p.m.; some secs.	Ditto (Buchner).
"	12	Saxony.........................	....	....	8 p.m.	Bright white, then yellow; train 9 seconds. From R A. 97°, Decl. + 9° to R. A. 101°, Decl. + 40° (Buchner).
"	13	Westphalia	.. . .	....	. .. .	Fireball (Buchner).
"	14	Ibid	.. ..	....	7.17 p.m.	Red; very brilliant; length of path more than 90° (Buchner).
"	19	Ibid	. . ...	....	7 p m.	In Bootes (Buchner).
"	27	Kurrachee, India	....	....	9.20 p.m.	Fireball, due south to Pleiades; 2 or 3 seconds; blue.
"	30	Switzerland..........	.. ..	....	....	Large meteor (Buchner).
"	Apr. 14	London	8 > ♃	....	7.42 p.m.	Fireball; lasted 3 seconds for 40° path.
"	20	Krain, Austria	....	from Lynx to Gemini.	7.55 p.m.; 8 seconds.	Ditto; variable light (Buchner).

1862.	Apr. 23	Athens	. . . ...	....	10.13 p.m	Fireball (Buchner).
,, *	June 4	Rimini, Urbino	....	E.S.E. to W.N.W.	8.30 p.m.	Ditto; fine bolide; brilliant white; detonated.
,,	12	Rhenish Prussia	.. .. ..	....	9.15 p.m.	Brilliant fireball. From R. A. 175°, Decl. +15° to R. A. 152°, Decl. +24° (Buchner).
,,	15	Munich	$\frac{1}{8}$ moon	Cassiopeia to Ursa Major.	10.30 p.m.	Fireball; yellow (Buchner).
,,	23	Australia	.. .. ..	....	... .	Ditto.
,,	25	Westphalia	. . .	....	11.35 p.m.	Ditto; reddish. From R. A. 213°, Decl. + 7° to R. A. 204°, Decl. −8° (Buchner).
,, *?	July 9	St. Louis, Missouri	. . . .	.. ..	. . ..	Iron-fall? (Sill. Journal, November 1862).
,,	28	Istria	. . ...	....	2 p.m.	Fireball; in sunshine (Buchner).
,,	Aug. 14	Westphalia	4′–6′	.. ..	9.45 p.m.; 4 seconds.	Bolide; yellow; train; from $\alpha=203°$, $\delta=+54°$ to 187, +36 (Buchner).
,,	20	Ibid	3′–4′	....	10 p.m.; $2\frac{1}{2}$ seconds	Ditto, reddish; from 4, + 4·5 to 31, + 8·5 (Buchner).
,,	21	Ibid	. .	....	....	Ditto; train; from 230, +72·5 to 229·5, +57 (Buchner).
,,	23	Georgia, U. S.	large	S.W. to N.E.	4 p.m.	Fireball, like a flaming sword high up in air.
,,	23	Weston-super-Mare	.	horizontal	9.55 p.m.	Ditto, lighted up sky, towards west; left a luminous streak or band.
,,	Sept. 19	London, Edinburgh, Notts, Normandy; Worcester.	=moon	N.N.W.; R 1, 2 radiant.	10.15 p.m.	Fireball; globular nucleus; bluish; sparks and streak; 83 miles over Canterbury to 33 miles over Oxford; diameter of ignited globe equal 36 feet.
,,	19	Reigate; Southampton	large	....	6.10 p.m.	Fireball; seen by daylight; rapid.
,,	25	Paris	> Venus	....	5.45 p.m.	
,,	25	Weston-super-Mare, Essex; N. Wales, Paris.	$=\frac{1}{2}$ moon	....	6.20 p.m.: 10 seconds.	Ditto; nucleus surrounded with a halo; 2 seconds for 20°; burst into many small balls.
,,	10	London	large	....	5 a.m.	Ditto; large disk; large as a plate.
,,	Oct. 3	Vienna	$\frac{1}{5}$ moon	. .	7.35 p.m.	Ditto, light yellow; tail of 30° long.
,, *	7	Klein-Menow, Mecklenburg	16 lbs.	....	1.30 p.m.	Stonefall.
,,	15	Senftenberg, Berlin	7′ *d.*	....	9.1 p.m.	Fireball; greenish; 2 or 3 seconds.
,,	15	Ibid	5′ *d.*	....	9.14 p.m.	Ditto ditto.
,,	15	Prague	6′ *d.*	....	9.24 p.m.	Ditto ditto; brilliant train.
,,	15	Bohemia	4′	Pole-star to S.W.	9.30 p.m.; 2 to 3 secs	Bolide; reddish.
,,	26	Mugeln, Lippe	..... .	....	. ...	Fireball, in S.E. (Buchner)
,,	26	Weston-super-Mare	....	....	7.45 p.m.	Ditto? sudden light, 1 second.
,,	27	Troppau	... .	. ...	6.30 p.m.	Ditto (Buchner).
,,	Nov. 1	Seville, Spain	....	. .....	.	Stonefall.
,,	2	Glasgow	$\frac{2}{3}$ moon	.. ..	10 p.m.	Fireball; white and reddish sparks.
,, *	5	Lancashire	5′ *d.*	. .. .	6 p.m.	Ditto.

Catalogue of *Luminous Meteors and Aërolites* (*continued*).

Year.	Day of month.	Locality.	Size or weight.	Direction.	Duration; rate; hour	Remarks, &c.
1862.	Nov. 16	London; Weston	4′ *d.*	....	10.45 p.m.	Fireball.
"	19	Westphalia	....	....	4.28 p.m.; 5 seconds.	Bolide; light blue; from $\alpha=359°$, $\delta=+71°$ to 354, $+47$ (Buchner).
"	19	Ibid	....	....	....	Ditto; train from 73, $+46$ to 74, $+45$ (Buchner).
"	23	Weston-super-Mare	$=\frac{1}{4}$ moon	....	8 30 p.m.	Fireball; 4° in 1 second, slow; reddish.
" *	26	Leeds; Selkirk	$\frac{1}{4}$ moon	S.E.	6.45 p.m.	Ditto; rapid; detonation heard; burst; coloured.
"	26	Melbourne, Australia	=moon	.. ..	7.45 p.m.	Ditto; path 45°.
" *	27	All over England and Wales; N. France.	=moon	N.E. to S.W.; G radiant.	5 45 p.m.	Ditto; brilliant; lasted 6 seconds; bluish white: from over mouths of Scheldt to mouth of Seine; 30 miles to 28 miles; train of sparks; detonation at Caen.
"	28	Westphalia	3′–4′	... .	5.13 p.m., slow.	Fireball; burst without detonation; from $\alpha=334°$, $\delta=+10°$ to 347, -28 (Buchner).
"	30	Ibid	.. .. .	....	7 32 p.m.	Bolide; train; from 265, $+45$ to 255, $+38$ (Buchner).
"	Dec. 3	Vienna	..	. . . ..	8 50 p.m.	Fireball, in E.; bluish white.
"	4	Ibid	....	S.W. to S.	7.16 p.m.; 10 to 15 secs	Ditto, with sparks; white.
"	10	Weston	....	....	.. .. .	Ditto; bolide; bluish.
"	11	Westphalia	5′–6′	.. ..	8.42 p.m.	Bolide; jerking motion; from $\alpha=106°$, $\delta=+31°$ to 113, -1 (Buchner).
"	12	Ibid	....	.. .. . .	7.3 p.m.	Ditto; train; path eurved; convex to N.; from 112, $+39$ to 127, $+47$ (Buchner).
,	12	Ibid	=Venus	.. ..	7 5 p.m.	Ditto; rose upwards; from 106, $+43$ to 105, $+56$ (Buchner).
"	12	Ibid	.. ..	.. ..	.. .. . .	Ditto; train; from 25, $+58$ to 11, $+51$ (Buchner).
"	15	Dordogne, France	2 > Venus	. ...	....	Fireball; bolide.
"	21	Lesina	$\frac{1}{2}$ moon	.. . ...	7 30 p.m.	Ditto; red train; detonated.
"	21	Hull	$=\frac{1}{4}$ moon	E. to W.	4 20 p.m.	Ditto; very slow; long bright train.
1863. *	Jan. 2	Breslau, Silesia	large	W.	5 p.m.	Ditto; detonation.
"	3	Wells	$\frac{1}{2}$ moon	N. to W.	7.30 p.m.	Ditto; brilliant.
"	6	Hamburg; Sweden	large	....	night.	Ditto; also at Stettin, Denmark, **Magdeburg.**
"	7	Dresden	. . ..	N.E.	$6\frac{1}{4}$ p.m.	Ditto; bluish, then reddish.
"	7	Holland	.. . .	N.	6.30 p.m.	Ditto; 2 seconds; Corona to Lyra.

1863.		Jan. 13	Greenwich	3 > Venus	....	3 seconds	Ditto; 12° path; oval; no train.
"		27	Perth; Stirling	$\frac{1}{3}$ moon	N.E.	5 p.m.	Ditto; lasted 4 seconds, fell ⊥ down in N.E.; rose-coloured.
"		30	Bannockburn	large	⊥ in south	6 p.m.	Fireball.
"		Feb. 7	Edinburgh; Fife; Berwick	$\frac{1}{2}$ moon	N.W. to S.E.	$6\frac{1}{2}$ p.m.	Ditto; brilliant; sparks; white, reddish; twisted streak left. Also seen in London and Dublin.
"		13	Bautzen	....	....	7 p.m.	Fireball.
"		13	Manchester; S. Scotland	$\frac{1}{7}$ moon	N.E.	11.30 p.m.	Ditto; reddish; sparks; 5 seconds; tail and body equal 1°; oval.
"		15	Folkstone	....	in S.E.	$9\frac{1}{4}$ p.m.	Fireball; brilliant; slow; white.
"		15	Giessen, Germany	large	⊥ in W.	$9\frac{1}{2}$ p.m.	Ditto; bluish white; 4 seconds: probably same as last.
"		20	Ibid	large	in S.E.	$6\frac{1}{2}$ p.m.	Fireball; train of a greenish hue; no detonation.
"		24	Salzburg	....	N.W.	2 a.m.	Ditto.
"	*	Mar. 4	Westphalia; Belgium; Manchester; Kent.	=moon	N. to S.	6.36 p.m., G. M. T.	Ditto; visible over an area of 100,000 square miles; 187 miles in $4\frac{1}{2}$ seconds, or 41 miles a second; from 88 miles over North Sea to 17 over South Brabant; detonations; orbit hyperbolic (see Brit. Assoc. Report, 1863, p. 321).
"		10	Weston-super-Mare	large	....	7.35 p.m.	Fireball; shaped like a dumb-bell!
"	*	12	Isle of Rhodes	large	....	1 a.m.	Ditto; magnificent meteor, followed by detonations.
"		17	Ibid	....	....	7 p.m.	Ditto; fine bolide.
"		23	Manchester; London; Wales	....	....	8.30 p.m.	Ditto; bolide; oval; rocket-like; greenish white.
"		25	Kent	5 > ♃	....	$3\frac{1}{2}$ seconds	Ditto; expanded and collapsed, blue, red; no train.
"		Apr. 13	Sheffield	large	....	8 15 p.m.	Fireball; brilliant; 60° path in 20 seconds; left a train of sparks.
"		20	London	....	....	....	Fireball; like a rocket.
"		May 4	Brighton	....	....	11.30 p.m.	Ditto; equal light of moon; stationary and revolving! dropping balls of fire; lasted 3 or 4 seconds.
"		24	Southsea	$\frac{1}{2}$ moon	stationary	$8\frac{1}{2}$ p.m.	Fireball; pear-shaped; burst.
"	*	June 2	Buschof, Courland, Russia	....	....	$7\frac{1}{2}$ a.m.	Stonefall.
"		6	London	4 > Jupiter	....	....	Fireball.
"		July 19	Birmingham; Kent; Hereford; Weston-super-Mare.	large	⊥ in N.W.	$8\frac{1}{4}$ p.m.; slow.	Ditto; daylight; zigzag vaporous streak left for 25 minutes! burst near horizon (see Brit. Assoc. Report, 1863, p. 265).
"		28	Switzerland	....	....	noon	Fireball, in bright sunshine.
"	*	Aug. 8	Pillistfer, Russia	....	....	$12\frac{1}{2}$ p.m.	Stonefall.
"		21	Athens	....	....	....	Fireball; train lasted 5 minutes; golden green (Schmidt).
"	*	11	Shytal, Dacca, India	5 lbs.	E. to W.	$11\frac{1}{2}$ a.m.	Fireball, accompanied with meteor and detonation.
"		16	Sheffield	> Venus	....	....	Ditto; globular.

Catalogue of Luminous Meteors and Aërolites (continued).

Year.	Date of month.	Locality.	Size or weight.	Direction.	Duration; rate; hour.	Remarks, &c.
1863.	Aug. 10	Weston-super-Mare	6 > Venus	....	11 p.m.	Fireball; prismatic sparks; 3 seconds.
,,	10	North Italy	$\frac{1}{6}$ moon	....	9.30 p.m., M. T.	Ditto; bluish; Polaris to Arcturus; scintillated; train became serpentine.
,,	10	Isle of Paxo.	large	S.W.	10.4 p.m.	Fireball; perhaps same as last.
,,	29	Kent	3 > Venus	......	2 seconds	Ditto; globular; no train.
,,	Sept. 6	Posen	....	N.W.	.....	Ditto; trained.
,,	7	Cille	....	E. to W.	....	Ditto; greenish.
,,	9	Nottingham	$\frac{1}{3}$ moon	....	8 26 p.m.	Ditto; left a train for 3″; went 102° path in 6 seconds; oval.
,,	11	Queenstown, Ireland	large	S E.	8 45 p.m.	Ditto: lighted up the harbour; moved rapidly.
,,	12	Athens	......	S W.	......	Ditto; brilliant; greenish; train lasted for a long time.
,,	13	Kent	3 > Venus	....	7.20 p m.	Fireball.
,,	18	Athens	large	S.W.	8 p.m.	Ditto; greenish.
,,	21	Hastings	large	S.W. to N.E.	1.50 a m.	Ditto; moved horizontally near horizon.
,,	Oct. 9	Greenwich	.	N. to S.	6 p.m.	Ditto; bright; still daylight.
,,	15	Nottingham, Kent	$\frac{1}{3}$ moon	....	10 p.m.	Ditto, at first 1st mag.; blue; train lasted 10′: also seen at Cheltenham.
,,	16	Westphalia	....	N. to E.	6 11 p m	Fireball; pear-shaped bolide.
,,	19	Athens	$\frac{2}{3}$ moon	W.	80° in 14″	Ditto; oval; examined through a telescope; several heads; greenish; began as a 4th magnitude star (Schmidt).
,,	17	Malaga	large	....	.....	Fireball.
,,	23	Switzerland	....	......	midnight	Ditto; trained; greenish.
,,	24	Leipzig	.....	S. to N.	...	Ditto.
,,	Nov. 11	Bautzen	large	N. to S.	...	Ditto.
,,	18	Manchester	$\frac{2}{3}$ moon	W. to N.	10.30 p.m.	Ditto; lasted 4 seconds.
,, *	23	Hanover; Bremen	.....	E. to W.	....	Ditto; brilliant; followed by a detonation.
,,	29	Weston-super-Mare	$\frac{2}{3}$ moon	....	8.45 p.m.	Ditto; in east; 15° path, ⊥ down.
,, *	Dec. 1	Switzerland	.....	......	1 a.m.	Ditto; detonated.
,, *	5	Whitehaven; Hull; Liverpool; Dublin; Kent.	$\frac{1}{2}$ moon	N.W. to S.E.	4″	Ditto; from 90 miles over Wigtonshire to 17 over Fleetwood; turned in its course; burst; detonation in 4′.
,, *	7	Tirlemont, Belgium	....	....	11 a.m.	Stonefall; great detonation (Comptes Rendus).
,,	8	London	....	....	......	Fireball.
,, *	10	Trebizonde	....	....	3 a.m.	Stonefall? and detonation (Haidinger).
,,	17	Newcastle-on-Tyne and Gloucester.	....	in S.W.	3 seconds	A fine meteor.
,, *	22	Manbhoom, Bengal	...	....	9 a.m.	Stonefall; detonation over 30 miles square.

1863.	Dec. 27	Kent; Somerset; Worcester, Mendip Hills.	= moon	Pleiades to S. horizon.	6 50 p.m.; 20 seconds.	Bluish green, then reddish; increased from a point to diameter of moon; divided into two, followed by a stream of fire.
"	28	Athens	large	....	6 p.m.	Fireball; from Perseus to γ Pegasi.
"	31	Naugard	3 > Venus	....	1 second	Ditto: trained; 8.40 P.M.
1864.	Jan. 3	Liverpool, Essex	large	....	8.25 p m.	Ditto; pear-shaped; bluish; tail; sparks.
"	7	Somersetshire	$\frac{2}{3}$ moon	....	8.40 p.m.	Ditto ditto; bluish green; tail; 10 seconds.
"	16	Bonn	...	S.S W.	$6\frac{1}{4}$ a.m.	Ditto; brilliant; trained.
"	19	Hungary	...	....	6 20 a m.	Ditto; trained.
"	23	Liverpool	large	....	8.30 p.m	Ditto.
"	21	Vienna	...	S.S.W.	$8\frac{1}{4}$ p.m.	Ditto.
"	21	Kent	...	...	8.40 p m.	Ditto; bright; low down in north.
"	Feb. 2	Surrey	...	...	.	Ditto, bolide; α Hydræ to horizon; rapid.
"	7	Liverpool	large	in N.W.	$6\frac{1}{4}$ p.m	Ditto; began near α Cephei.
"	9	Syros, Ægean Sea	...	....	11 p m.	Ditto; Perseus to Arcturus; greenish; brilliant.
"	10	Wolverhampton	$\frac{1}{6}$ moon	N. to S.	$10\frac{1}{4}$ p m.	Ditto, no train; 3 seconds for 20° path; began at β Canis Minoris.
"	Feb. 10	Naples	large	W.	$6\frac{1}{2}$ p.m.	Fireball; 4 seconds.
"	22	Mologa, Russia	....	in N.	9 p.m	Ditto; stationary a long while, in Ursa Major.
"	Mar. 6	Westphalia	....	...	....	Ditto.
"	6	Manchester	...	...	....	Ditto; bluish.
"	12	Ibid	$\frac{1}{4}$ moon	......	......	Ditto. burst with sparks, reddish.
"	25	Hants	large	W N.W.	$8\frac{1}{2}$ p.m.	Ditto; cast shadows; path 100°; below Great Bear to above Orion; sparks, tail, sparks.
"	Apr. 5	Brussells	$\frac{2}{3}$ moon	....	10 p.m.	Fireball; or 1863.
"	7	Belgium	......	S. to N.	$8\frac{1}{4}$ p m.	Ditto.
" *	12	Nerst, Russian Courland	...	.....	4.45 a m.	Stonefall.
"	25	Coventry, &c.	3 > ♃	......	11.30 p m.	Fireball, well-defined disk; bluish; 4 seconds.
"	May 4	Puycharnand, France	3 > Venus	...	3 30 p m.	Ditto: $2\frac{1}{2}$ seconds; α Cephei from ζ Draconis.
" *	14	Orgueil, Montauban, Toulouse, &c., S W. France.	= moon	W. to E.	8 p m.	Stonefall and meteor; detonation in $3\frac{1}{3}$ minutes; height. first seen, 50 kilos., last seen at explosion, 17 kilometres; sp. gr. 2·56. Carbonaceous stone.
"	12	Ipsara, Mediterranean	brilliant	N.E. to S.W.	midnight	Fireball.
"	17	Weston-super-Mare	large	⊥ N.	4 p m.	Ditto; conical; seen in daylight; 45° altitude.
"	28	Hay, South Wales	4 > ♃	⊥ down	10 p m.	Ditto; white; increased from a point, sparks.
"	June 6	Paris	6 > Venus	....	$9\frac{3}{4}$ p.m.	Ditto; conical; path 100°; near Corona to Capella.
"	7	Jersey	$\frac{1}{4}$ moon	in S E.	7 p m.	Ditto; nearly horizontal at 20° altitude; slow motion.
"	10	Bagshot, Surrey	large	in S.E.	8 p.m.	Fireball; 25° path; rapid; reddish; left to right.
" *	26	Dolgowola, Volhynia	....	....	....	Stonefall.
"	27	Athens	....	....	....	Fireball; greenish; trained; 2 seconds.
"	July 2	Kirmi, Greece	....	....	....	Ditto.

Catalogue of Luminous Meteors and Aërolites (continued).

Year.	Day of month.	Locality.	Size or weight.	Direction.	Duration; rate; hour.	Remarks, &c.
1864.	July 4	Ajaccio	....	N.W. to S.E.	7.10 p.m.	Fireball; brilliant.
„	4	Wolverhampton; Conway...	½ moon	E. to W.	10 p.m.	Ditto; 5 or 6 seconds; white. At Wolverhampton; directed from Polaris to Libra.
„	5	Kent	½ moon	S.W. to N.E.	0.30 a.m.	Fireball; not tailed; collapsed; golden colour several seconds.
„	13	Boston, U. S.	....	....	....	Fireball.
„	16	Athens	> ♃	S.	....	Ditto; yellow.
„	28	Kephissia, Greece	....	....	3 seconds	Ditto; green; trained.
„	24	Nottingham	large	....	10 p.m.	Ditto; slow, bluish; rose up in north.
„	29	Kephissia, Athens	....	....	....	Ditto; much > ♃; train lasted 3 minutes.
„	Aug. 1	Piræus, Greece	....	N.	....	Ditto; train lasted several minutes.
„	2	Nottingham	....	N E. to S.W.	10.15 p.m	Ditto; large; moved across zenith; blue.
„	3	Cherbourg, France	large	W.S.W. to E.S.E.	8 30 p m.	Ditto; slow; conical; yellowish; burst with sparks.
„	6	S. England; France; Belgium, &c.	⅓ moon	S.W. to N.E.	10.20 p m.	Ditto, blue, train 17 seconds, in the east in Kent, 50° high, dazzling.
„	9	Paris; Kent	½ moon	....	0.52 a m.	Fireball, small bolide; yellow; 1 second, 12° path; like ball of a Roman candle.
„ *	10	Milos; Athens	....	....	6.40 p.m	Stonefall?; detonating meteor; train and smoke lasted 16 minutes. Doubtful whether two stones fell at Polinos.
„	10	Stelvio; Baveno; N. Italy...	⅕ moon	S.W. to N.E.	8.45 p m.	Fireball, reddish; like a rocket.
„	11	Greenwich	....	....	9.36 p.m.	Fireball; white-greenish; 1½ second; from B Camelopardi, in Kent, began as a 3rd mag. star.
„	13	Greenwich; Kent	....	....	9.40 p.m.	Ditto, like a flash of lightning; train lasted 2 secs.; from zenith near β Draconis to Corona.
„	10	Sussex	....	....	9 p m.	Fireball.
„	16	St. Gotthard	large	E. to W.	0 40 a.m	Ditto, bright as noon day; wavy streak for several minutes.
„	21	Kephissia, Greece	....	....	....	Fireball, red; train lasted several minutes.
„	21	Edinburgh	large	....	rapid	Ditto; 8 15 P.M.
„ (a)	26	South Wales; Grantham; Wolverhampton; Bristol.	½ moon	S.E. to N.W.	11 p.m.	Ditto; orange; 6 seconds; pear-shaped; began as a streak; blue or green, as seen in some places.
„ (b)	31	Sussex; Exeter	....	in S.W.	10½ p.m.	Fireball; bolide, comet-like tail; path of 45° arc.
„	Sept. 3	Spain (coast of)	....	S E.	....	Ditto; brilliant.
„	6	West Linton, Scotland	large	....	8.55 p.m.	Ditto; burst like a bomb with much light.
„	6	Ibid	large	....	9.5 p.m.	Ditto; left a long train lasting some time.

(a) A fuller description, giving heights, velocities, &c. of the Meteors of July 4, August 6, 9, 10, 26, will be found p. 92 of Brit. Assoc. Report for 1864.
(b) And also for the meteors of August 10, 31, November 11, 20, and December 9, in the volume for 1865.

1864 *	Sept. 8	Sicily	....	S.E. to N.W.	3 p.m.	Fireball, detonation; train lasted 1 hour.
"	16	Palermo	....	....	5 seconds	Ditto; white, brilliant.
"	20	Attica, Morea	large	....	4 a.m.	Ditto; train lasted 10 minutes.
"	20	Münster	....	....	....	Ditto; dazzling white.
" *	24	Mont de Marsan, Tarbes; Nerac; Pau; Balearic Isles.	large	N. to S.	12.20, noon	Ditto; like a flash of lightning; train of smoke left for several minutes; report like cannon.
"	25	Westphalia; Munster	....	....	....	Fireball; brilliant; white.
"	30	Vienna	....	....	....	Ditto ditto; blue.
"	Oct. 1	Westphalia	large	....	....	Ditto ditto.
"	4	Ibid	....	....	$8\frac{1}{2}$ p.m.	Ditto?; a dark object seen for 11° arc slowly moving across the Milky Way (Prof. Heis).
"	5	Paris	....	....	....	Fireball.
"	7	Westphalia	....	N.	....	Ditto, large and brilliant.
"	10	Paris	....	S.S.W.	6.8 p.m.	Ditto; like a rocket.
"	10	Wolverhampton	....	N. to S.	2.40 a.m.	Ditto; small bolide; white; sparks; 4 seconds; horizontal.
"	20	Westphalia	....	....	5.11 p.m.	Fireball; reddish, brilliant.
"	20	Ibid	....	....	7.30 p.m.	Ditto; reddish, very brilliant; trained.
"	25	Ibid	....	....	7.37 p.m.	Ditto; dazzling, white, reddish.
"	Nov. 11	France; Westphalia; Kent	= moon	N.N.E. to S.S.W.	$5\frac{1}{2}$ p.m.	Ditto; oval; dazzling train; horizontal, N. to S. nearly; 4 seconds.
"	19	Athens	....	....	....	Fireball; green; 1 second.
"	20	Lichtenberg	....	....	....	Ditto; brilliant.
"	20	Leeds, Leamington	= moon	....	9 p.m.	Ditto; bluish; burst.
"	23	Ibid	....	....	....	Ditto; yellow.
"	28	Herrieden	....	....	....	Ditto; brilliant; α Andromedæ to E Cygni; sparks.
"	29	Tülich	....	....	2 seconds	Ditto; intense green; trained.
"	29	Paris	....	S.W. to N.E.	....	Ditto.
" *	20	(All over) England	$\frac{2}{3}$ moon	N.E. to S.W.	8.50 p.m.	Ditto; blue; detonation in Rutlandshire; burst into three parts; lasted 3 seconds.
"	Dec. 3	Kent	= moon	E. to W.	3.30 a.m.	Fireball; oval; 30° to 40° path.
" *	4	Taranaki (New Zealand)	= sun	....	2 a.m.	Stonefall; immense detonation; two stones said to have fallen, one in sea and one at Turakina.
"	4	Paris	= 5′ *d.*	N.N.W.	7 p.m.	Fireball; train 2 seconds; Capella to $\frac{1}{2}$ (α, β) Ursæ Majoris.
"	9	Kent; Manchester	3 > Venus	....	3.50 a.m.	Fireball; white, green; cast shadows.
"	9	Paris	....	....	9.7 p.m.	Ditto; small brilliant bolide.
"	10	Westphalia; Münster	....	....	....	Ditto; long train, lasting several seconds; sparks.
"	11	Ibid	5′ diam.	....	....	Ditto; dazzling white.
"	11	Berlin; Tegas	....	....	....	Ditto; brilliant; reddish.
"	11	Putney, London	....	....	2 a.m.	Ditto; small bolide; bright.
"	13	Manchester	....	⊥ in N.W.	midnight	Ditto; 2 seconds; bluish.

Catalogue of Luminous Meteors and Aërolites (continued).

Year.	Day of month.	Locality.	Size or weight.	Direction.	Duration; rate; hour.	Remarks, &c.
1864.	Dec. 13	London	......	....	7 p.m.	Fireball.
1865.*	Jan. 19	Goruckpore, India	....	....	....	Stonefall.
,,	Feb. 15	....	....	....	....	Fireball.
,,	17	Auteuil, France	large	S. to N.	5 50 p.m.	Ditto, at Sèvres; horizontal; S. to N.; streak 10′.
,, *	21	Forfar; Fifeshire	= moon	N.E. to S W.	$9\frac{1}{4}$ p.m.	Ditto; 5 seconds; pear-shaped; white, followed by a rumbling noise.
,,	Apr. 12	Weston-super-Mare	2 > Venus	....	9 10 p.m.	Fireball; pear-shaped; burst; illuminated the landscape; blue; 3 seconds.
,,	25	Frant. Sussex	large	W. to E.	$11\frac{1}{2}$ p.m.	Ditto; blue; slow; globular.
,,	27	Woodstock, Oxon	2 > Venus	W. to E.	$10\frac{1}{4}$ p.m.	Ditto; reddish brown; rapid; horizontal; no train or noise.
,, ?*	30	Manchester; Weston-super-Mare.	12′ d.	....	0.43 a.m.	Fireball; from a point: several expanding maxima; ? rumbling noise 8′ after.
,, *	May 23	Gopalpore, India	......	....	6 p.m.	Stonefall.
,, *	June 19	Mouza-Khoorna	......	....	......	Stonefall in India.
,,	30	Athens	......	....	....	Fireball; greenish; one also on the 24th June.
,,	July 8	Dresden	....	....	....	Ditto; trained; path 40°.
,,	12	Westmoreland	> Venus	in W.	....	Bolide, with train.
,,	15	Warrington	large	....	11.35 p.m.	Fireball; like a rocket; 75° path; left a phosphorescent train.
,,	19	Bristol	large	S. to N	$10\frac{1}{2}$ p.m.	Fireball; tail of fire; blue; several seconds.
,,	24	Athens	....	....	....	Ditto; yellowish; train lasted 30 seconds (Schmidt).
,,	25	Ibid	......	....	0 5 second	Ditto ditto ditto 10 minutes; ditto.
,,	26	Ibid	......	....	....	Ditto; very brilliant.
,,	27	Ibid	.....	....	0·8 second	Ditto; train lasted for 21 minutes (Schmidt).
,, *	Aug. 12	Dundrum, Tipperary	$4\frac{3}{4}$ lbs.	....	7 p.m.	Stonefall; detonation; meteor not seen; one stone.
*	20	Erinpoorah, Agra	$3\frac{1}{2}$ lbs.	....	1.30 p.m.	Stonefall.
,,	14	Munster	......	....	....	Fireball; three small fireballs seen this night.
,, *	25	Aumale, Algiers	70 lbs.	....	$11\frac{1}{2}$ a.m.	Stonefall; two stones fell, sp. gr. 3·65.
,, *	25	Shergotty, India	......	....	9 a.m.	Ditto.
,,	Sept. 5	Hastings	......	....	midnight	Fireball; white; globular like the moon.
,, *	7	Mudoor, Asia	......	....	7 a.m.	Stonefall.
,,	16	Hay, Hereford	> Venus	....	....	Bolide; yellow and pinkish sparks; pear-shaped.
,,	19	London	$\frac{1}{5}$ moon	....	10.20 p.m.	Fireball; burst with sparks; long train.
,,	20	Munster	....	....	....	Ditto; dazzling white; two seen this evening.
,,	24	Greenwich; Manchester; Hampshire.	3 × ♃	....	8.30 p.m.	Ditto; blue, red train; broke into fragments; 38 miles over Gloucester to 27 miles over Bath; velocity 24 miles; radiant-point in Capricornus.
,,	25	Weston-super-Mare	$\frac{2}{3}$ moon	....	9.20 p.m.	Fireball.

1865.	Sept. 26	Thirsk; Kent	large	....	8.55 p.m.	Brilliant fireball with train, from Auriga; height at disappearance 76 miles; velocity 57 miles.
,,	26	Eastbourne; Greenwich; Weston-super-Mare	$\frac{2}{3}$ moon	....	9.20 p.m.	Fireball; train; green or blue; illuminated the country; from Polaris; height 50 to 30 miles.
,,	30	Vienna	....	....	....	Fireball, brilliant; blue.
,, *	Oct. 3	Moffat, Dumfriesshire	....	....	....	Ditto; brilliant bolide; report heard in 30 seconds.
,,	16	Mentone, N. Italy	large	Pisces to Aquila	10 p.m.	Ditto; train.
,,	Nov. 6	Lancaster	large	E. to W.	6 to 7 p.m.	Ditto.
,,	13	Hawkhurst; Flimwell	= Venus	Orion to S.W.	12 24 a.m.	Bolide of November shower; pear-shaped; train.
,,	13	Hawkhurst, Kent	> Venus	α Leonis	12.44 a m.	Ditto; almost stationary; greenish; streak 15 secs.
,,	13	London	= Venus	δ to E Leonis	1.36 a.m.	Bolide.
,,	13	Streatham, London	= Venus	....	5 a.m.; 4 seconds.	Ditto; yellow; no train.
,,	13	Ibid	= moon	from Leo	5 a.m.	Ditto of November shower; blue; train $\frac{1}{2}$ minute.
,,	13	Ibid	$\frac{2}{3}$ moon	from Leo	5.7 a m.	Ditto ditto ditto; train 1 minute.
,,	13	Ibid	= moon	from Leo	5.12 a.m.	Ditto ditto; purplish; train $\frac{1}{2}$ minute.
,,	13	Ibid	= Venus	from Leo	5.17 a.m.	Ditto ditto ditto; train several seconds.
,,	13	Dresden	$\frac{1}{3}$ moon	....	....	Fireball; white.
,,	13	Ibid	....	....	....	Ditto; light blue, brilliant.
,,	13	London; Manchester; Plymouth, Boulogne, &c.	3 × Venus	....	5.42 p.m.; $2\frac{1}{2}$ seconds	Bolide; increased from 3rd mag. star; globular; sparks; train 1 secon; from 80 miles over Aylesbury to 80 miles over Hartley Quay; velocity 66 miles, burst; no detonation.
,,	13	London; Yarmouth; Cambridge.	3 or 4 × Venus	E. to W.	10.50 p.m.	Fireball, with yellowish streak; through Ursa Major
,,	14	Hawkhurst, Kent	4 × Venus	in Leo	12.34 a.m.	Bolide of November shower; pear-shaped; green; red streak, 2 seconds.
,,	18	Wimbledon; Cambridge, &c.	> Jupiter	η to γ Ursæ	4.30 p m.	Fireball with train; divided into two; seen in twilight.
,,	21	The Nore to Henley-on-Thames.	$\frac{1}{4}$ moon	E. to W.	....	Fireball; 75 miles in $6\frac{1}{4}$ seconds; 19+11 miles velocity; 41 to 27 miles high; from Cetus.
,,	24	Lewisham, Kent	2 × Venus	....	8.20 p.m.	Fireball, with train; from u Lyncis to χ Ursæ Majoris.
,,	24	Cambridge Observatory	large	E. to W.	9.10 p.m.	Fireball; blazed like a Roman candle ball.
,,	28	Cromer, Norfolk	= Venus	....	3.7 a.m.	Ditto; globular; θ Draconis to ϕ Herculis.
,,	Dec. 7	Pontypool, N. Wales	large	N.E. to N W.	evening	Ditto; bright crimson at last; broke into fragments.
,,	7	Vannes, France; Brest; Bordeaux, &c.	= moon	W. to E.	7.30 p.m.	Ditto; detonating; 55 to 35 miles high over Quimper to mouth of Loire; velocity 10 miles.
,,	9	Dresden	$\frac{1}{3}$ moon	....	....	Fireball; brilliant green.
,, *	9	Charleston, U.S.	....	....	$8\frac{1}{2}$ p.m.	Ditto; bright light and meteoric detonation; meteor.
,,	25	Weston-super-Mare	= Venus	....	7.34 p.m.; $2\frac{1}{2}$ seconds.	Ditto; yellow; pear-shaped; red streak for 4 seconds.
1866.	Jan. 6	Sunderland, Wisbeach	2 × Venus	....	10.5 p.m.	Fireball; blue; streak $\frac{1}{2}$ minute; ζ Eridani to π Ceti.

Catalogue of Luminous Meteors and Aërolites (continued).

Year.	Day of month.	Locality.	Size or weight.	Direction.	Duration; rate; hour.	Remarks, &c.
1866.	Jan. 11	S. England; Ticehurst, Hay, &c.	10′	....	9.55 p.m.	Ditto; white; slight train; path 160°; 85 miles over Paris to 95 miles over Cork; 700 miles in 6 or 8 seconds!! from Hydra.
„ ?*	22	Torquay	large	Pleiades to the moon.	7.53 p.m.; nearly 1′.	Fireball, blue, broke into red fragments; doubtful detonation.
„	31	Sandhurst, Australia	....	W. to E.	....	Fireball; very brilliant, even in full moonshine.
„ *	Feb. 22	N. Scotland; Ballater, &c...	> moon	....	$8\frac{1}{2}$ p.m.	Ditto; vivid light; blue; tail of fire; detonation after 2 minutes.
„	Mar. 15	Penrhyn, Cornwall	= moon	S. to N.	11.50 p.m.	Fireball; light as day; bluish white with long tail; in the N.
„	17	Greenwich and Lewisham...	= Venus	Dubhe to Cassiopeia.	10.47 p.m.; 1 second.	Fireball; yellow; fine train.
„	Apr. 8	Monsheim	large	E. to W.	9 p.m.	Ditto; intensely brilliant; bluish white; sparks (Buchner).
„	19	Paris Observatory	large	....	evening	Fireball; burst twice.
„	27	Giessen	....	S. to N.	....	Ditto; green, brilliant (Buchner).
„	May 16	Greenwich	= Venus	in S.	11 p.m.: 1 second.	Ditto; bluish white.
„	17	Ibid	= Venus	β to α Leonis	10.38 p.m.	Ditto; blue; no train.
„ *	28	Bustee, Goruckpore	....	....	....	Stonefall, in India.
„ *	30	St. Mesmin, Aube, France...	= moon	W. to E.	4 a.m.	Three aerolites fell, 3, 4, and 8 lbs., with usual meteoric sounds and fireball.
„ *	June 9	Knyahinya, Hungary.........	= moon	E. to W.	5 p.m.	Stonefall and meteor; detonation; 1000 stones; one 6 cwt.
„ *	20	Calais; Boulogne; France, and England.	½ moon	N. to S.	11 a.m.; $3\frac{1}{2}$ seconds.	Aërolitic; white; red sparks; train of smoke 15 minutes; violent detonation; 15 miles over Calais to $4\frac{1}{2}$ miles over Montreuil and Boulogne; velocity 9 miles; seen in sunshine.
„	July 17	Eidfjord, Norway	⅓ moon	in W.N.W.	8.52 p.m.	Fireball, in daylight; green, with long red tail; train of white smoke 12 minutes.
„	26	N. York	....	E. to W.	¾ second	Brilliant meteor; 30° length of path.
„	Aug. 8	S. England	½ moon	N.E. to S.W.	8.15 p.m.	Fireball; kite-shaped; very brilliant, in full twilight.
„	21	Vichy, France.................	....	....	evening	Fireball (see 'Comptes Rendus,' vol. lxiii. p. 407).
„	Sept. 28	Giessen	.. ..	E. to W.	7.48 p.m.; 8 seconds.	Fireball (Buchner).
„	Nov. 1	Dijon, France..................	⅓ moon	....	....	Ditto, with train.
„	30	Llanès, Santander, Spain ..	....	....	....	Stonefall.

Fourth Report on Dredging among the Shetland Isles. By J. Gwyn Jeffreys, *F.R.S.*

In spite of the weather, which was worse than usual in this stormy region, some additional results of no slight interest were obtained. The three requisites of such enterprises (time, money, and experience) were not wanting; and the valuable cooperation of Mr. Norman, Mr. Waller, and Mr. Dodd, aided by a good yacht and crew, and by a large stock of apparatus, left nothing to desire except calmer seas. Dr. Edmondston and his family again did all in their power to promote our endeavours; and Mr. Cheyne, of Edinburgh, kindly placed his house at Tanwick at our disposal.

Discoveries in natural history are of several kinds, all of which are nearly equally important:—1. New species or forms. 2. Geographical distribution. 3. Habits of animals, including in the present case those supposed to be dependent on the depth of water. 4. Geological relations. 5. Extraneous incidents.

All these I will now notice as regards the Mollusca. Other branches of the marine Invertebrata will be treated of by Mr. Norman, Mr. Waller, and Dr. M'Intosh; and Dr. Gunther has kindly promised to report on a few small fishes caught in the dredge.

1. *New Species.*—The species I am about to enumerate are new to the British fauna, but not to science.

Terebratella Spitzbergensis, Davidson.

A fresh and perfect, although dead specimen occurred in 80–90 fathoms off Unst. The only locality hitherto recorded for this shell in a living state is Spitzbergen. It was found by Hisinger and myself in a fossil state at Uddevalla, and last year by Messrs. Crosskey and Robertson in another raised sea-bed near Christiania. There is, of course, a possibility that the Shetland specimen also may be fossil; but it has all the appearance of being recent; and *Terebratula cranium* and *T. caput-serpentis* (both of which are likewise arctic species) live in the same place where this specimen of *Terebratella Spitzbergensis* was dredged.

Rhynchonella psittacea, Gmelin.

A specimen (unfortunately broken in dredging) was found with *Terebratella Spitzbergensis, Terebratula cranium,* and *T. caput-serpentis.* This was filled with soft mud, in which was a fresh, but dead young specimen of *R. psittacea.* I had on a former occasion dredged a full-grown specimen and a young one (both quite perfect, although not living) off Unst. In 'British Conchology,' vol. ii. pp. 22 and 23, is an account of all the specimens said to have been taken by Capt. Laskey and others in the British seas; and I am still convinced that most of these reported discoveries were mistakes, and that some of the specimens are fossil. The present case is free from doubt, except on the latter ground. Single valves of *Pecten Islandicus, Tellina calcaria,* and *Mya truncata,* var. *Uddevallensis,* are not uncommon on the northern and eastern coasts of Shetland, and were procured with *T. Spitzbergensis* and *R. psittacea*; but the former had an unmistakeably fossilized or chalky aspect, and never were perfect or had the valves united. It seems to be an established rule that in all species of marine invertebrate animals, which are distributed through the European seas, northern specimens excel in size those from the south; and thus the comparative size of living and dead specimens of arctic species found in the Shetland seas may serve as an additional test to distinguish which of

the latter are recent or surviving and which fossil or relics of the glacial epoch. The two Brachiopods in question must, I think, stand or fall together as British. Mr. Davidson (the great authority on this abnormal class of the Mollusca) says that, under the circumstances I have mentioned, "there appears to be a probability that these two species may occur somewhere in the neighbourhood—if not quaternary; but if this last, I hardly think they would have been so perfect and fresh as you describe them to be." Professor Lovén, who has examined my specimens, considers them recent. According to Professor Sars, *R. psittacea* inhabits the coast of Finmark, as far south as Tromsö (69° 40′ N. lat.), at depths of from 20 to 80 fathoms. Mr. M'Andrew dredged it off Drontheim and in Upper Norway, at depths of from 40 to 150 fathoms. Drontheim lies in 63° N. lat., Unst in about 61°.

Leda pernula, Müller.

A valve, apparently fossil, was dredged on the northern coast; and several valves in a fresh state (partly covered with a glossy epidermis) and a small perfect but dead specimen were dredged in St. Magnus Bay, on the west coast, at a depth of from 60 to 80 fathoms. As no glacial fossils of arctic species occurred on the west coast, I have no hesitation in regarding *L. pernula* as British. I had in former expeditions dredged small valves and a complete pair east of Shetland and in the Hebrides. This species inhabits the Scandinavian coasts, as far south as Kullen in Sweden, from 20 to 150 fathoms; and M'Andrew records a depth of 160 fathoms: it is a circumpolar species, and also one of our post-tertiary or quaternary fossils.

The next two species are especially interesting, in respect both of novelty and of the classification of the Mollusca. They belong to the class Solenoconchia (Solenoconches, Lacaze-Duthiers, or Scaphopoda, Bronn), which is represented by the genus *Dentalium*. I have elsewhere so fully treated of this peculiar class that I will now offer merely a few remarks on the genus *Siphonodentalium* of Sars, to which or an allied genus the species now about to be noticed must be referred. *Siphonodentalium* (perhaps the type of a separate family of Solenoconchia) is distinguished from *Dentalium* by having an extensile worm-like foot, the disk of which expands in the shape of a flower and is furnished with a spike, by the mouth or anterior orifice of the shell being obliquely truncated—in *Dentalium* it is circular,—and by the posterior or smaller orifice having its margin serrated or slit on each side, instead of this orifice being furnished with a short pipe or having its margin slit on one side only. I am inclined to refer one of the species now discovered as British to the genus *Siphonodentalium*, and the other to the genus *Cadulus* of Professor Philippi*. In the latter genus (which Philippi proposed for the reception of a small Sicilian fossil—his *Dentalium ovulum*) the shell is not cylindro-conical as in *Siphonodentalium*, but is tumid in the middle or anterior portion, sometimes awl-shaped; and the mouth is encircled by a narrow rim. In *Cadulus* the shell is quite smooth, transparent, and lustrous; in *Siphonodentalium* it is striated or exhibits the lines of growth, and is semitransparent. The long-lost *Dentalium gadus* of Montagu, an allied species (*D. clavatum* of Gould) from the China Sea, another species which I observed in the late Mr. Cuming's collection, from Mindanao (erroneously named *D. acuminatum*, Deshayes), and *D. coarctatum* of Lamarck (a tertiary fossil) apparently belong to *Cadulus*, and certainly not to *Ditrupa* (properly *Ditrypa*), a genus of testaceous Annelids the shell of which is different in structure and composition from that of *Cadulus* or of

* Moll. Sic. ii. p. 209.

Siphonodentalium, the mouth is contracted or pinched-in, and the animal is annulose and has a circular operculum. On the other hand, several kinds of shelly cases described as *Dentalia* really belong to *Ditrypa*. If *Cadulus* is not generically distinct from *Siphonodentalium*, the former of these names has priority; and we shall thus be able to expunge a more than sesquipedalian name from the terminology of the Mollusca. The diagram now exhibited is an enlarged representation of the figures of *S. Lofotense* and *S. subfusiformis*, from an admirable paper by Professor Sars, published in the Transactions of the Academy of Sciences at Christiania for 1864; and it will serve to explain the nature of these extraordinary mollusks. One of our species is

Siphonodentalium Lofotense, Sars

("Malacozoologische Jagttagelser," in Vid.-Selsk. Forh. 1864, p. 17, figs. 29–33), ranging from the Loffoden Isles to Christianiafiord, at depths of between 30 and 120 fathoms. It was rather plentiful among sandy mud in St. Magnus Bay, at the depth of from 60 to 80 fathoms; and I had found it in 1846 when dredging off Skye, in 1864 off Unst, and last year in the Minch. The shell may easily be passed over—as it was by me—for the young of *Dentaliam entalis*; but it is more curved and cylindrical, the mouth and corresponding lines of growth slope backwards, and the margin of the posterior orifice is regularly jagged (having two slight notches on each side), and this extremity does not form a bulbous point in the fry. One of the characters given by Sars ("margine aperturæ posterioris integro") should be amended. My observation of the animal agreed with his, except that the foot is vermiform and has a fine point, the disk being expanded and assuming the shape of a flower only when the *Siphonodentalium* wishes to obtain a fulcrum and keep its place in the sand. The foot of *Nucula* and *Leda* is somewhat similar, its disk when expanded resembling the leaf of a palm. Another species of *Siphonodentalium* proper is *Dentalium quinquangulare* of Forbes, from the Ægean (80–230 fathoms), which M'Andrew afterwards dredged off the coasts of Portugal and Spain in 5–30 fathoms, and named (lapsu calami) *D. quadrangulare*; this species Sars lately procured from the Loffoden Isles and Christianiafiord in 50–300 fathoms, and described as *S. pentagonum*. The coincidence of the first and last of these specific names is curious. *D. bicarinatum* of Deshayes (a tertiary fossil) may also be referable to the genus *Siphonodentalium*. *D. bifissum* of Searles Wood, from the Coralline Crag, is possibly the type of another genus, for which I would suggest the name of *Dischides*. This species has been dredged in a living state off Gibraltar by Mr. M'Andrew *. I suspected that *D. bifissum* might be the tube of a young *Teredo norvegica*, on account of its having a septal process within the posterior orifice: at all events my remark is justified by the affinity which exists between the *Teredinidæ* and the Solenoconchia.

The second species of this class is

Cadulus subfusiformis, Sars

(*Siphonodentalium subfusiforme*, l. c. p. 21, figs. 36–44), having a Norwegian distribution equally extensive with that of *S. Lofotense*, but attaining a greater depth, viz. from 50 to 300 fathoms. I noticed specimens among the fossils collected last year by Messrs. Crosskey and Robertson in a raised sea-bed at Barholmen, near Christiania. It occurred on the Unst ground, in 80–90 fathoms, and was apparently not rare. Mr. Peach detected a specimen in looking over some sand which I dredged there in 1864; this I at the time

* It inhabits also the European and African coasts of the Mediterranean.

regarded as a *Ditrypa*. The margin of the posterior orifice has two slight indentations or notches, one on each side; and Sars's statement that the margin is entire was perhaps founded on imperfect specimens. *C. subfusiformis* may be known from *C. gadus* not only by its much smaller size, but also by having the greatest width or diameter in the middle (instead of in the upper or anterior part), and by the posterior or narrower part being abruptly curtailed. *C. gadus* is awl-shaped, and has a tapering extremity; *C. subfusiformis* is gibbous. Whether *C. gadus* inhabits our seas is questionable. Montagu says*, "This is a pelagic species, found in many parts of the British Channel, and is known to mariners by the name of 'hake's tooth,' who frequently find it within soundings, adhering to the log-line (as we are informed), but most likely to the plumb-line." My specimens are from the collections of Dr. Turton and Mr. George Humphreys; the latter dealt almost exclusively in exotic shells. Rang placed *D. gadus* in his genus *Creseis*, among the Pteropoda; but Philippi rightly objected to such a classification, because the shells of all Pteropods are closed at the smaller end†.

The sixth and last addition to our molluscan fauna is

Utriculus globosus, Lovén

(*Amphisphyra globosa*, Ind. Moll. Scand. p. 11). Two living specimens were dredged in St. Magnus Bay, with *Leda pernula* and *Siphonodentalium Lofotense*. Its distribution, according to Professor Lovén, extended from Finmark to Bohuslän in the south of Sweden; and through the kindness of the discoverer and Professor Lilljeborg I have been enabled to compare the Shetland specimens with those from the Scandinavian coasts. I mention this, because (before I was thus favoured, and when I had only Lovén's description to consult) I mistook this species for another, which I have lately described as *U. ventrosus*, from Skye.

2. *Geographical distribution.*—The accompanying list‡ of all the Mollusca hitherto observed in Shetland and the adjacent seas will serve to show the relations which exist between these and the Mollusca of the north and south of Europe. The number of Shetland species is 363, of which 315 inhabit the north and 245 the south of Europe. The total number of species of British Mollusca, so far as I have yet worked out the subject, is 712. It may be remarked what a scanty proportion the land and freshwater Mollusca of Shetland bear to those of Great Britain, viz. 23 species only out of 122. The marine species, however, are 340 out of 590—although the Zetlandic Nudibranchs and Cuttles have not been well examined, and, of the former, 28 only out of 110 have been as yet observed.

Some species are now for the first time recorded as Zetlandic, e. g. *Terebratella Spitzbergensis*, *Montacuta tumidula*, *Siphonodentalium Lofotense*, *Cadulus subfusiformis*, *Rissoa proxima*, *Odostomia clavula*, and *Utriculus globosus*. Other species, either rare or local, which I had previously dredged on the eastern and northern coasts, were found this year on the western coast also. Such are *Pecten Testæ*, *Lima Sarsii*, *L. elliptica*, *Leda pernula*, *Axinus ferruginosus*, *Isocardia cor*, *Tellina balaustina* (one living specimen being fully an inch in breadth), *Panopea plicata*, *Rissoa Jeffreysi*, *Aclis supranitida*, *A. Walleri*, *Odostomia minima*, *O. eximia*, *Eulima intermedia*, *Natica sordida*, *Aporrhaïs*

* Test. Brit. i. p. 496.

† I have now ascertained that *Siphonodentalium Lofotense*, *S. quinquangulare*, *Cadulus ovulum*, *C. subfusiformis*, and *Dischides bifissus* inhabit the Gulf of Naples. 1st January 1868.

‡ This list will be published in the concluding Report next year.

Macandreæ, Cerithiopsis costulata, Buccinum Humphreysianum, Columbella nana, Pleurotoma brachystoma, Cylichna acuminata, Philine quadrata, and *P. nitida.*

3. *Habits of Animals.*—Species which were supposed to inhabit shallow water only were found living at considerable depths. In this category may be mentioned *Natica catena,* which was dredged alive in from 40 to 50 fathoms. Capt. Thomas informs me that he also dredged this species in the Orkneys living at the same depth. A dead specimen of *Stilifer Turtoni* was procured with *Natica catena.* Bathymetrical conditions are not of so much consequence to the Mollusca as a suitable habitation and a good feeding-ground. We had the good fortune of dredging in 170 fathoms—a greater depth than had been previously explored in the British seas. This was about forty miles N.N.W. of Unst. The ground was stony intermixed with patches of sand. The greatest depth recorded as having been dredged in our seas was 145 fathoms, by Admiral Beechey, off the Mull of Galloway. The following is a list of the Mollusca which I examined from our dredging in 170 fathoms:—

Living.—Brachiopoda: *Terebratula cranium,* young; *T. caput-serpentis,* young; *Crania anomala.* Conchifera: *Anomia ephippium,* young; *A. patelliformis,* var. *striata; Lima subauriculata,* young; *Leda pygmæa; Montacuta substriata,* on *Spatangus meridionalis; Venus ovata; Lucinopsis undata,* young; *Saxicava rugosa.* Solenoconchia: *Dentalium entalis,* var. *anulata.* Gastropoda: *Trochus occidentalis; Eulima bilineata; Natica Montacuti; Trophon Barvicensis.*

Dead.—Conchifera: *Pecten septemradiatus,* a fragment; *P. tigrinus,* ditto; *P. similis,* a single valve; *Crenella decussata,* fragments; *Nucula nucleus,* single valves; *N. tenuis,* ditto; *Leda minuta,* a single valve; *Limopsis aurita,* small but fresh single valves; *Arca pectunculoides,* single valves; *Lucina borealis,* perfect; *Axinus Croulinensis,* single valves; *Cardium fasciatum,* ditto; *C. minimum,* ditto; *Astarte sulcata,* ditto; *Venus lincta,* ditto; *Tellina balaustina,* a fragment; *Psammobia Ferroensis,* ditto; *Mactra solida,* var. *elliptica,* single valves; *Scrobicularia prismatica,* a fragment; *Thracia papyracea,* var. *villosiuscula,* young; *Neæra cuspidata,* a fragment. Gastropoda: *Tectura fulva,* var. *albula; Propilidium ancyloides; Emarginula fissura; Trochus amabilis,* young; *T. millegranus,* ditto; *Turritella terebra,* var. *nivea; Natica Alderi; Trichotropis borealis; Buccinopsis Dalei,* a fragment; *Fusus gracilis,* young; *F. propinquus,* ditto; *Defrancia teres; D. linearis,* var. *æqualis,* a fragment; *Pleurotoma costata,* ditto; *Cylichna alba,* ditto. Pteropoda: *Spirialis retroversus; Clio* or *Cleodora pyramidata,* a fragment.

Of these species sixteen were living, and thirty-eight dead—in all, fifty-four. They comprised some rarities, viz. *Terebratula cranium, Limopsis aurita, Axinus Croulinensis, Trochus amabilis, Buccinopsis Dalei,* and *Cylichna alba.* The shells were of the usual colour; indeed this was brighter and darker in living specimens of *Venus ovata* and *Eulima bilineata* than in average examples of the same species taken in a few fathoms. The notion that colour is absent or fainter in shells from deep water seems to be quite unfounded.

4. *Geological Relations.*—Fossil shells (being apparently relics of the glacial epoch) occurred in 170 fathoms, and higher up to 80 fathoms. They were chiefly *Pecten Islandicus, Tellina calcaria, Mya truncata,* var. *Uddevallensis, Saxicava rugosa,* var. *Uddevallensis, Mölleria costulata,* and *Trochus cinereus.* All these species and varieties inhabit high northern latitudes, and none of them have been discovered living in our seas. No such fossils were detected on any part of the western coast of Shetland.

5. *Extraneous incidents.*—In the dredged stuff taken from a depth of about

85 fathoms, on a soft sandy bottom, twenty-five miles N.N.W. of Unst, I found the canine tooth of an animal of the weasel tribe; and Mr. Waller found the shoulder-blade of a much smaller quadruped. These occurred within a comparatively small space, although not together, and they were unaccompanied by any other land organisms. The socket of the tooth and the bone were eroded. It is possible that the tooth was that of a tame ferret, which was accidentally killed in 1862 and thrown into the sea in Balta Sound, at a distance of about thirty-five miles from the place where the tooth was dredged. The tide sets with great rapidity in that direction; and when the carcase became distended by the gases evolved during putrefaction, it must have floated for some time. The bone is supposed by Mr. Boyd Dawkins to be that of a bat; this may have been eaten by a snowy owl, and disgorged or voided on its way back to the Faroe Isles or Iceland. I mention this curious circumstance to show that some bones of quadrupeds as well as of man may be preserved for a long time in "the slimy bottom of the deep," without being disturbed by the naturalist. When we consider the vast extent of the sea-bed, and the very trifling and unfrequent operations of the dredge (the one being measured by square nautical degrees, and the other by square yards), we ought not to be surprised that the remains of drowned mariners—at least their teeth—are not thus brought to light. Clarence's dream (the creation of a sublime poet) is never likely to be verified by modern research.

I have had much pleasure in presenting a collection of the rarer shells to our national Museum.

Subjoined are letters from Dr. Gunther and Mr. Boyd Dawkins:—

"DEAR SIR,—The fishes collected by you by means of the dredge, at a depth of from 80 to 90 fathoms, at the Shetland Islands, belong to four species, all being new to the British fauna. Singularly enough, two belong to Mediterranean species—viz. a Dragonet, *Callionymus maculatus* (Bonap.) and a Sand-Launce, *Ammodytes siculus* (Swains.). The two others appear to be undescribed: one is a Rockling, distinguished by its very large eyes, for which I propose the name of *Motella macrophthalma*; the second a Goby, which I dedicate to its discoverer under the name of *Gobius Jeffreysii*. I will furnish you with descriptions of the two new species, and remain

"Yours very truly,

"*J. Gwyn Jeffreys, Esq., F.R.S.*" "A. GÜNTHER."

"Upminster, Romford, Essex.
"August 28, 1867.

"MY DEAR SIR,—I have carefully examined the remains found under such interesting circumstances. The tooth approaches nearer to the left lower canine of the ferret (*Putorius furo*) than to any other teeth in the Museum of the College of Surgeons. From so small a portion I can hardly infer the species of the animal; but if its possessor was not a Ferret, he was a Ferret's first cousin, one of the Mustelines, who died in the prime of life. The corrosion of the fang is very curious, and cannot be the result of the waste of the sea: it seems to be the result of the action of an acid, which has been prevented from attacking the crown by the crystalline structure of the enamel. Nearly all the gelatine has disappeared from the fang. Its age would be best arrived at by the character of the sea-bottom. If from a muddy deposit, probably it is of that age; if from a rocky bottom, its age is altogether uncertain. It is not more recent-looking than many of the Pleistocene bones I have dug out of caverns. The second fragment seems to be a portion of the scapula of a bat; but its condition does not allow of a very accurate determination. If the two

were dredged up near each other, there is probably a deposit of bones at the spot whence they were obtained, similar to that of the east coast. Their discovery is of very great interest, and I am only sorry that I can add so little to their elucidation. "I am, my dear Sir,

"*J. Gwyn Jeffreys, Esq.* Yours truly,
25 *Devonshire Place.*" "W. Boyd Dawkins."

P.S. I may add that, before I left Shetland, Dr. Saxby kindly undertook, at my suggestion, to ascertain whether mammalian bones deposited in the sea would be eroded, and by what means.

Preliminary Report on the Crustacea, Molluscoida, Echinodermata, and Cœlenterata, procured by the Shetland Dredging Committee in 1867. *By the* Rev. Alfred Merle Norman, *M.A.*

The further investigation is carried on in the Shetland seas, the more deeply interesting does the study of the fauna of that portion of our country become. Dredging in the depths of those northern waters, in which there is almost invariably a heavy sea,—at one time sweeping across the Atlantic, at another rolling away from Greenland, at another (as was the case for many weeks together during the present summer) running from Spitzbergen and the ice-floes of the Arctic Ocean, accompanied by a keen, cutting north-east wind,—is not altogether pleasant work for the naturalist. Yet, trying and difficult though the dredging may be, there is none to be compared with it in the British Islands; and every fresh summer your Dredging Committee have spent in investigating the marine fauna of Shetland, they have returned home only the more convinced of the greatness of the field of research which remains to be explored. Every square mile of the sea seems to have treasures to give up unknown to us before; and the extent of the riches which lie there, one, two, three, four hundred fathoms deep, will perhaps never be known in our day. The extreme interest which attaches to the Shetland sea is the circumstance that it is the trysting place of the northern and southern faunas: the warm influence of the Gulf-stream impinging on the western coast coaxes on many a species of sunnier climes to extend its migration northwards, while the cold winds and waves which issue from the Pole and come drifting round the North Cape and Loffoden Isles, account for the many Arctic forms which, stunted in size and numerically scarce, are yet able in the equable temperature of the abyss of the Shetland waters to hold out against those southern influences so detrimental to *their* constitutions. The product of the dredging of the present year promises a rich harvest of additions to the British fauna; and in those classes of which I more especially undertake the examination I have already found most important results; at the same time the few notes which at this time are given must be only regarded in the light of a preliminary report. The passing of every specimen under the microscope, as must be done in the determining of all the smaller Crustacea, Hydrozoa, &c., and the dissection and mounting of every specimen of the former not at once recognized, is necessarily a work of time; and very much remains to be examined, especially among the Copepoda, Ostracoda, &c.

Crustacea.

First we will take the Crustacea. In my Report of Hebridean Dredging last year, I traced the genus *Xantho* northwards as far as the Isle of Mull; and I have now to record the occurrence of a young specimen of *X. rivulosa* some 350 miles further north, off the Island of Balta. A fine undescribed *Pagurus* is perhaps nearest allied to *P. cuanensis*. The hand is remarkably broad, the finger especially so, and is furnished with three much elevated ribs, one at each margin, and the third central; the margins are denticulately spined, and the wrist and upper edge of the second and third legs are also spinous; the species may be named *Pagurus tricarinatus*. Among the Mysidea are two genera not yet recorded as British. *Nematopus serratus*, G. O. Sars, differs from *Mysis* chiefly in the structure of the abdominal feet and of the central tail-plate; the species, when alive, is a beautiful little thing, having its white body prettily painted with red, and the eyes, which are large and kidney-shaped, of a brilliant ruby colour. The other genus is one which I would establish (*Gastrosaccus*) for the reception of the *Mysis sancta* of Van Beneden (=*M. spinifera*, Goes); the marsupial pouch, instead of being an appendage, as in *Mysis*, of the last two thoracic legs, is attached to the last thoracic and first abdominal feet; and the first abdominal feet in the female, instead of being the smallest, are the most fully developed, and consist of an elongated basal joint and two short branches; while in the male the third abdominal foot is the more especially developed sexual organ. *Gastrosaccus sanctus*, though now first recorded, has been for many years in my collection, and was first sent to me by Mr. Edward, of Banff, who procured it in the Moray Firth. *Mysis flexuosa*, *Spiritus*, *vulgaris*, *Griffithsiæ* and *Didelphys*; *Diastylis lamellata*, *Iphithoe serrata*, and *Lamprops rosea* were the remaining Stomapods.

Among the Amphipoda the difficult family Lysianassidæ is well represented by *Callisoma crenata*, *Anonyx longicornis*, *longipes*, *minutus*, *obesus*, and *Holböllii* (=*denticulatus*, Bate), and by three additions to our fauna,—*Anonyx nanoides* of Lilljeborg, procured among Laminariæ at Lerwick and at Hillswick, *Anonyx tumidus* of Kroyer, found in a sponge dredged thirty-five miles N.N.W. of Unst in 170 fathoms, and *Stegocephalus ampulla*, Phipps. This last truly arctic species was dredged in 60–70 fathoms in St. Magnus Bay; the single specimen procured is, as compared with Spitzbergen examples, for which I am indebted to Professor Lovén, as a pigmy to giants, bearing about the same proportionate size to its northern brethren as do the *Leda pernula*, taken in the same spot, to their Greenland relatives. Indeed, as a rule, those arctic Amphipods, which occur also on the British coast—for example, *Gammarus locusta* and *Amathilla Sabini*—attain a much greater development within the Arctic circle. The *Anonyx tumidus*, however, of Shetland, shows no difference of size from Spitzbergen specimens. It may be questioned, however, whether this is a truly arctic species; for although long known in the north, it has recently been recorded by Professor Heller from the Adriatic Sea; and its discovery this year in Shetland gives an intermediate locality. The fact that it is an essentially parasitic species, which is never found except either in the branchial sac of Tunicata or in sponges, and that it is also an inhabitant of very deep water, may have led to its having been hitherto overlooked.

Passing over all other Amphipoda hitherto known to our fauna, I have to announce the following important additions:—a species allied apparently to

Calliopius, having subequal ovate gnathopods; but the peduncles of the antennæ are longer and the flagella shorter than is usual in that genus, and the meros of the pereiopods is not produced backwards and downwards; a *Pleustes* (?), with smooth body, and hands somewhat resembling in structure those of the second pair in *Amphilochus manudens*, Bate, with the palm similarly crenated, but much more oblique; a new genus allied in general characters of eyes, of gnathopods, and pereiopods, especially in the broadly flattened meros and carpus of the last pair, to *Haploops*, but having the antennæ furnished with an appendage; an *Atylus*, remarkable on account of the extraordinary length and slenderness of the legs, and having the hinder margin of all the abdominal segments serrate across the back with a larger central spine; a *Cyrtophium*, having the segments of the body furnished with spine-formed tubercles, which are much larger than those of *C. tubercularis*, Bruzelius, from which it also differs in having the hand of the second gnathopods shorter and broader, and the spine of the meros large and strong; and a *Corophium*, with longer posterior uropods and less strongly developed antennæ than the species hitherto described.

Of Isopoda the very rare species *Paratanais rigidus*, B. & W., *Phryxus abdominalis*, parasitical in *Hippolyte pusiola*, *Leptaspidia brevipes*, B. & W., and *Cirolana spinipes*, B. & W., were found, together with what appears to be a new species of the last genus. The form comes nearest to the *Æga crenulata* of Lutken, agreeing with it in having the telson truncated and denticulate at the extremity; the general outline of the telson, however, differs from Lutken's figure, and the uropods are of different form.

My attention was especially directed during the expedition to the Entomostraca, and an enormous stock of material has been accumulated for examination. It has as yet scarcely been touched, but the following new things have already been observed. First and foremost is *Cypridina Norvegica* of Baird—the largest of all European Ostracoda; next is a very fine arctic Cythereis, *Cythereis costata* of Brady, only known previously from the Hunde Islands; *Pontocypris hispida*, *Cythereis crenulata*, and *Cythereis abyssicola* are species recently described by G. O. Sars from the Norwegian seas; and besides these there are four species of *Cythere*, one *Cytheridea*, two *Cytherura* (including by far the finest species of the genus yet known), and a species allied perhaps to *Argillœcia cylindrica* of Sars, which appear to be new to science. There are also several members of the families *Alteuthidæ* and *Harpacticidæ*, together with a curious form, parasitic in *Didemnaum gelatinosum*, which I am unable as yet to determine, and believe to be undescribed.

The very rare and curious burrowing barnacle, *Alcippe lampas*, Hancock, was inhabiting shells of *Fusus antiquus*, dredged five miles off Balta.

Tunicata.

The Tunicata dredged were very few, but included *Ascidia rudis*, Alder, a large species discovered in 1861, and this year procured between the Islands of Whalsey and Balta. In a cave in St. Magnus Bay, *Thylacium Normani*, Alder, was living in great numbers; it was only previously known in the Channel Islands, where it covers a large portion of the side of the famous Gouliot Cave. *Salpa runcinata* was met with in some numbers in the open sea thirty miles N.N.W. of Burrafirth Lighthouse, but was not observed nearer shore.

Polyzoa.

Two or three fragments of the beautiful coral *Hornera violacea* of Sars were dredged between Balta and Whalsey in 40–50 fathoms. A fine specimen procured by Mr. Barlee has long been in my collection. I found it among his Polyzoa bequeathed to me marked "Shetland." The confirmation of the discovery is, however, of importance, and this fine addition to our fauna is now for the first time made public. A very remarkable *Lepralia*, found between tidemarks at Balta, differs widely from all known species. The mouth of the hyaline, punctate, ovate cells, instead of being sessile, is elevated to the extremity of a long tube which rises from the polyzoary; immediately below the origin of this tube is an ovate avicularium. A small patch of this species, consisting of a few cells only, in a very imperfect state, which I had met with among the things procured in Shetland by Mr. Barlee, was sent by me some years ago to Professor Busk, who attached to them the manuscript name *Lepralia tubulosa*, a title which the species may most appropriately bear. There is also a new *Eschara*, and a few other species were found which are additions to the very long list of Shetland Polyzoa previously known to me.

Echinodermata.

Among the Echinodermata the fact of *Cidaris papillata* and *Spatangus meridionalis* having been dredged in considerable numbers, living in 100–110 fathoms, about thirty miles N.N.W. of Unst, is extremely interesting. The Cidaris has never before been dredged in our seas, the few specimens known having been obtained from fishermen's lines. We kept it alive for some time, and found it to be remarkably sluggish in its movements. The Spatangus was not known anywhere north of the Mediterranean until 1864, when two specimens were obtained near the same spot in which it has this year been met with in greater profusion. A second British specimen of *Archaster Parelii* was found near the same spot as the species just referred to. An *Echinocardium* was dredged by Mr. M'Andrew many years ago on the south side of Bressay Island, Shetland, and described and figured in the 'Annals of Natural History' for 1857, under the name of *Amphidotus gibbosus* of Agassiz. The species was dredged this year in St. Magnus Bay, and I have seen a second specimen procured by Mr. D. Robertson in the Clyde district, and a third found by Mr. Hodge on the Durham coast. It is most certainly not the *Amphidetus gibbosus* of Agassiz, and I would propose to call it *Echinocardium pennatifidum*, on account of the character of the pedicellariæ, which are very different from the same organs in *E. ovatum*, its nearest ally, and remind us strongly of the form of fern leaves.

Cœlenterata.

Lastly, in briefly noticing the Cœlenterata, it is worthy of mention that *Stomphia Churchiæ*, *Bulocera Tuediæ*, and *Pennatula phosphorea*, the last in most extraordinary profusion, were found in St. Magnus Bay, and that *Rhizocline areolata*, *Merona cornucopiæ*, and *Dicoryne conferta*, live in about 50 fathoms, five to seven miles off Balta. In company with these last were thousands of a *Zoanthus*, which sometimes lives entirely free, at others coats the shells of small univalve mollusca and then destroys their substance. This *Zoanthus* is, I believe, the *Z. incrustatus* of Scandinavian writers, and I am now perfectly satisfied that it is distinct from the *Zoanthus Couchii*, and from a form, perhaps also distinct from *Z. Couchii*, which was found on this

and on previous occasions in Shetland inhabiting very deep water and living parasitic upon sponges, thus being of similar habit to that species which has excited so much controversy lately, which lives upon *Hyalonema mirabilis*. In the open sea to the north of Unst I had the delight of seeing in profusion two lovely oceanic Hydrozoa belonging to the genera *Diphyes* and *Physophora*. Unfortunately having no works upon the subject with me I was unable to determine the species, but I believe the former to have been *D. appendiculata*. *Diphyes* has only once before been observed in British waters, and *Physophora* was not known to inhabit them. The rapidity of growth in Diphyes is extraordinary, the cœnosarc of a specimen kept alive was developed nearly three inches in a single night.

These notes are necessarily brief, and I fear may have proved dry and uninteresting to the majority of the members in consequence of that very brevity. My excuse must be that it is much more easy to draw up a report of general interest when little has been done, and the habits and life-history of some particular animals can be dilated upon, than it is so to summarize the discoveries of a successful expedition as to make them in their necessarily condensed form interesting to others than purely scientific naturalists.

Report on the Foraminifera obtained in the Shetland Seas. By Edward Waller.

In making a report of the Foraminifera obtained in the several dredging expeditions to the Shetland Islands, undertaken by Mr. Jeffreys and his companions from 1861 to the present year (in all of which, except that of 1863, I was a party), it was a matter of immediate importance to consider some of the works recently published on the British Foraminifera, for the purpose of deciding upon the mode of classification, the nomenclature, and the enumeration to be adopted in presenting the results of our explorations.

Mr. Williamson's recent 'Foraminifera of Great Britain,' published by the Ray Society in 1858, illustrated with admirable plates, and containing generally very lucid descriptions, will necessarily be in the hands of all studying the British Foraminifera, and may be taken, without much change, as affording a fair representation of the then known forms which were sufficiently distinct to be named and figured.

The beauty of the objects and the information in the book will, doubtless, soon stimulate explorers elsewhere, as they have done on the Scottish and Durham coasts, to make additions to our species.

The subsequent work of Dr. Carpenter on the study of the Foraminifera, published by the Ray Society in 1862, was based on very extended inquiries into both recent and fossil Foraminifera by himself and Messrs. Parker and Jones, and opened up views of classification which differed very much from previous modes, including Mr. Williamson's.

Dr. Carpenter's system has regard more to th construction of the animal inhabitant than to the outline of the shelly covering, and seems at once to have a more natural foundation, and, from certain characters of the shell, suited to the animal construction, to afford a more obvious and accurate division of the objects. The new arrangement requires a considerable change in the names of species, &c.

I propose, therefore, in the appended list to follow the classification and nearly the nomenclature of Dr. Carpenter and his colleagues, and to take Mr.

Williamson's work as a basis for the enumeration of the various forms of our recent Foraminifera.

In taking this course, I but follow in the steps of Mr. H. B. Brady, who published in the Transactions of the Linnean Society, vol. xxiv., a list of the Shetland Foraminifera, derived principally from dredgings furnished by Mr. Jeffreys and myself, with some additions from my own examinations. His catalogue has been so carefully constructed, and his investigation of any doubtful species introduced into Mr. Williamson's book on questionable authority has been so full, that I am relieved from difficulties I should otherwise have been unable to surmount within the time elapsed since my return from the Shetlands, and I have little to do except to continue his work up to the present time.

Mr. Williamson describes 104 species and varieties, of which Mr. Brady remarks that three are most probably fossil, and that two others have been withdrawn as Mediterranean, introduced by accident. Deducting these, there remain 99 recent British Foraminifera known at that time. Mr. Brady, in his Shetland list, gives 92 of those, and adds 19 new forms, making 111 in that district, and 118 in Britain. Mr. Brady, in vol. i. of the Natural History Transactions of Northumberland and Durham, describes from those coasts 6 Foraminifera new to Britain; and in his report to this Association on the Foraminifera of the Hebrides as resulting from Mr. Jeffreys's dredging in 1866, he gives eleven more species, and I now add from the Shetlands one more new to Britain, raising its list to 136. I have also found four of the new Durham species in dredgings of 1864, but too late for Mr. Brady's publications, and in the present year's examinations three of the new forms of the Hebrides and two of Mr. Williamson's not before noted, thus bringing up the Shetland list to 121, or within 15 of the whole British forms.

That of those 136 species or varieties from the entire range of the British coasts so large a proportion as 121 should be found in a limited district at one extremity of the empire, is a result which I believe could scarcely be obtained in any other department of natural history; and it may, perhaps, be no unfair conclusion, from this and their bathymetrical conditions, that slight changes of climate have little influence on those low forms of life, while depth of water has greater power of limitation, some species being only known close to the shore or in very shallow water, while in the great depths are found only a few and different forms. It is, however, true that by the advance northward the Shetland Foraminifera approach more nearly to the Norwegian species and varieties than do those of the southern parts of England and Ireland.

I have many specimens from this year's dredgings which will require considerable time to work out satisfactorily. Some of them have been kindly examined by Mr. Rupert Jones, and I hope for his further assistance; and I expect that, in conjunction with Mr. Brady, I may be able, at no distant time, to have them fully described and figured. There are new forms of *Biloculina*, *Gaudryina*, *Dimorphina*, *Cornuspira* and, I believe, *Polytrema*, which will afford considerable additions to our known species, and, I think, prove that our Shetland dredgings have given satisfactory results in this branch of our fauna.

SUBKINGDOM PROTOZOA.
CLASS RHIZOPODA.
Order RETICULATA.
(*Foraminifera.*)
Suborder IMPERFORATA.
Family MILIOLIDA.

Genera, Species, and Varieties.	References to Williamson's 'Monograph.' Names.	Figures.
CORNUSPIRA, *Schultze.*		
foliacea, *Philippi*	Spirillina foliacea	199–201.
BILOCULINA, *D'Orb.*		
ringens, *Lamk.*	Biloculina ringens	169–171.
depressa, *D'Orb.*	" var. carinata	172–174.
elongata, *D'Orb.*	" var. Patagonica..	175 & 176.
sphæra, *D'Orb.*	....	....
contraria, *D'Orb.*	....	....
SPIROLOCULINA, *D'Orb.* ..		
limbata, *D'Orb.*	Spiroloculina depressa	177.
planulata, *Lamk.* ..	" " var. rotundata	178.
canaliculata, *D'Orb.* ..	" " var. cymbium	179.
excavata, *D'Orb.*	....	....
TRILOCULINA, *D'Orb.*		
trigonula, *Lamk*	Miliolina trigonula	180–182.
oblonga, *Montagu*	Miliolina seminulum, var. oblonga ..	186 & 187.
tricarinata, *D'Orb.* ...	....	....
QUINQUELOCULINA, *D'Orb.*		
seminulum, *Linn.* ...	miliolina seminulum	183–185.
subrotunda, *Montagu* .	....	....
bicornis, *W. & J.*	Miliolina bicornis	190–194.
secans, *D'Orb.*	" seminulum, var. disciformis	188 & 189.
Ferussacii, *D'Orb.*	" bicornis, var. angulata	196.
pulchella, *D'Orb.*	....	....

Family LITUOLIDA.

TROCHAMMINA, *P. & J.*		
incerta, *D'Orb.*	Spirillina arenacea...............	203.
inflata, *Montagu*	Rotalina inflata	93 & 94.
LITUOLA.		
scorpiurus, *Montfort* ..	....	....
Canariensis, *D'Orb.* ..	Nonionina Jeffreysii	72 & 73.
VALVULINA, *D'Orb.*		
Austriaca, *D'Orb.*	Rotalina fusca	114 & 115.

Suborder PERFORATA.

Family LAGENIDA.

LAGENA, *Walker.*		
sulcata, *W & J.*	Lagena vulgaris, var. striata........	10.
	" " var. interrupta	11.
	" " var. perlucida, parte	8.
	Entosolenia costata	18.
lævis, *Montagu*	Lagena vulgaris	5 & 5*a*.
	" " var. clavata........	6.
striata, *Montagu*......	Lagena vulgaris, var. gracilis	12 & 13.
	" " var. substriata	14.

Genera, Species, and Varieties.	References to Williamson's 'Monograph.' Names.	Figures.
LAGENA, *Walker.*		
semistriata, *Will.*	Lagena vulgaris, var. semistriata....	9.
	" " var. perlucida, parte	7.
globosa, *Montagu*	Entosolenia globosa	15 & 16.
marginata, *Montagu* ..	Entosolenia marginata	19–21.
	" " var. lucida ..	22 & 23.
	" " var. quadrata	27 & 28.
ornata, *Will.*	Entosolenia marginata, var. ornata ..	24.
	" " var. lagenoides	25 & 26.
pulchella, *Brady*	....	....
squamosa, *Montagu* ..	Entosolenia squamosa	29.
	" " var. scalariformis.	30.
	" " var. hexagona . .	32.
melo, *D'Orb.*	Entosolenia squamosa, var. catenulata	31.
caudata, *D'Orb.*	Entosolenia globosa, var. lineata ...	17.
distoma, *P. & J.*	....	....
crenata, *P. & J.*	....	....
Jeffreysii, *Brady*	....	....
NODOSARIA, *Lamk.*		
longicauda, *D'Orb.* ..	Nodosaria radicula................	36–38.
raphanistrum, *Linn.* ..	Dentalina subarcuata, var. jugosa ..	43 & 44.
pyrula, *D'Orb.*	Nodosaria pyrula	39.
DENTALINA. *D'Orb.*		
communis, *D'Orb.*	Dentalina subarcuata........... ...	40 & 41.
obliqua, *D'Orb.*	" " var. jugosa	42.
VAGINULINA, *D'Orb.*		
legumen, *Linn.*	Dentalina legumen............	45.
linearis, *Montagu*	" " var. linearis....	46–49.
CRISTELLARIA, *Lamk.*		
rotulata, *Lamk.*	Cristellaria calcar	52 & 53.
	" " var. rotifer	54.
crepidula, *F. & M.*	Cristellaria calcar, var. oblonga	55.
	" subarcuatula	56–59.
MARGINULINA, *D'Orb.*		
lituus, *D'Orb.*	Cristellaria subarcuatula, var. elongata	62.
LINGULINA, *D'Orb.*		
carinata, *D'Orb.*	Lingulina carinata	33–35.
GLANDULINA, *D'Orb.*		
lævigata, *D'Orb.*	....	....
POLYMORPHINA, *D'Orb.*		
compressa, *D'Orb.*	Polymorphina lactea, parte.........	145.
lactea, *W. & J.*	Polymorphina lactea, parte.........	146 & 147.
	" communis	153–155.
acuminata, *Will.*	Polymorphina lactea, var. acuminata	148.
oblonga, *Brown*	" " var. oblonga ..	149 & 149*a*.
concava, *Will.*	" " var. concava ..	151 & 152.
tubulosa, *D'Orb.*	" " var. fistulosa ..	150.
myristiformis, *Will.* ..	Polymorphina myristiformis........	156 & 157.
UVIGERINA, *D'Orb.*		
pygmæa, *D'Orb.*	Uvigerina pygmæa................	138 & 139.
angulosa, *Will.*	" angulosa	140.
	Family GLOBIGERINIDA.	
ORBULINA, *D'Orb.*		
universa, *D'Orb.*	Orbulina universa	4.
SPIRILLINA, *Ehrenb.*		
vivipara, *Ehrenb.*	Spirillina perforata...............	202.

Genera, Species, and Varieties.	References to Williamson's 'Monograph.' Names.	Figures.
GLOBIGERINA, *D'Orb.*		
bulloides, *D'Orb.*	Globigerina bulloides.............	116–118.
TEXTULARIA, *Defrance.*		
variabilis, *Will.*	Textularia variabilis	162 & 163.
	" " var. lævigata ..	168.
pygmæa, *D'Orb.*	" " var. spathulata	164 & 165.
difformis, *D'Orb.*	" " var. difformis ..	166 & 167.
sagittula, *Defrance.* ..	Textularia cuneiformis	158 & 159.
trochus, *D'Orb.*	" " var. conica ..	160 & 161.
BIGENERINA, *D'Orb.*		
digitata, *D'Orb.*	....	....
nodosaria, *D'Orb.*	....	....
VERNEUILINA, *D'Orb.*		
polystropha, *Reuss*	Bulimina { scabra, pl. 65 / arenacea, pl. 98 }	136 & 137.
BULIMINA, *D'Orb.*		
pupoides, *D'Orb.*	Bulimina pupoides	124 & 125.
marginata, *D'Orb.*	" " var. marginata	126 & 127.
aculeata, *D'Orb.*	" " var. spinulosa	128.
ovata, *D'Orb.*	" " var. fusiformis	129 & 130.
convoluta, *Will.*	" " var. convoluta......	132 & 133.
elegantissima, *D'Orb.* .	Bulimina elegantissima...........	134 & 135.
VIRGULINA, *D'Orb.*		
Schreibersii, *Czjzek.* ..	Bulimina pupoides, var. compressa ..	131.
BOLIVINA, *D'Orb.*		
punctata, *D'Orb.*	....	....
CASSIDULINA, *D'Orb.*		
lævigata, *D'Orb.*	Cassidulina lævigata	141 & 142.
crassa, *D'Orb.*	" obtusa...............	143 & 144.
DISCORBINA, *P. & J.*		
rosacea, *D'Orb.*	Rotalina mamilla	109–111.
ochracea, *Will.*	" ochracea	112 & 113.
globularis, *D'Orb.*	" concamerata (young)......	104 & 105.
Bertheloti, *D'Orb.*	....	....
PLANORBULINA, *D'Orb.*		
Mediterranensis, *D'Orb*	Planorbulina vulgaris	119 & 120.
Haidingerii, *D'Orb.* ..	....	....
Ungeriana, *D'Orb.*	....	....
TRUNCATULINA, *D'Orb.*		
lobatula, *Walker*	Truncatulina lobatula	121–123.
refulgens, *Montfort* ..	....	....
ANOMALINA, *D'Orb.*		
coronata, *P. & J.*	....	....
PULVINULINA, *P. & J.*		
repanda, *F. & M.*	Rotalina concamerata	101–103.
auricula, *F. & M.*	" oblonga	98–100.
concentrica, *P. & J.* ..	....	....
Karsteni, *Reuss*	....	....
ROTALIA.		
Beccarii, *Linn.*	Rotalina Beccarii	90–92.
nitida, *Will.*	" nitida	106–108.
orbicularis, *D'Orb.*	....	....
TINOPORUS, *Montfort.*		
lævis, *P. & J.*	....	....
PATELLINA, *Will.*		
corrugata, *Will.*	Patellina corrugata	86–89.

Family NUMMULINIDA.

Genera, Species, and Varieties.	References to Williamson's 'Monograph.'	
	Names.	Figures.
NUMMULINA, *D'Orb.*		
radiata, *F. & M.*	Nummulina planatula	76 & 77.
OPERCULINA, *D'Orb.*		
ammonoides, *Gron.* ..	Nonionina elegans	74 & 75.
POLYSTOMELLA.		
crispa, *Linn.*	Polystomella crispa	78–80.
striato-punctata, *F.&M.*	Polystomella umbilicatula	81 & 82.
	Polystomella ,, var. incerta	82*a*.
arctica, *P. & J.*	....	....
NONIONINA, *D'Orb.*		
turgida, *Will.*	Rotalina turgida	95–97.
umbilicatula, *Montagu.*	Nonionina Barleeana	68 & 69.
depressula, *W. & J.* ..	Nonionina umbilicatula, p. 97 ... Nonionina crassula, p. 33	70 & 71.
scapha, *F. & M.*	....	....
stelligera, *D'Orb.*	....	....

Appendix to the Fourth Report on Dredging among the Shetland Isles. Additions to the British Fauna. By DR. ALBERT GUNTHER, *F.R.S.*

ALTHOUGH we are very well acquainted with the marine fishes inhabiting the shores of Great Britain and Ireland, our knowledge of the pelagic and deep-sea forms is extremely scanty. Of the Dealfish (*Trachypterus arcticus*), a fish by no means uncommon in the northern and eastern seas of Scotland, I have never seen a British example in a good state of preservation. Now and then, after the gales of the vernal equinox, a mutilated specimen of the Ribbonfish (*Regalecus Banksii*) is drifted ashore, rarely to fall into the hands of a naturalist, generally to be cut up as bait for the lobster-pot. The British species of *Leptocephalus* is not better known than the allied forms from the Mediterranean and tropical seas. Others, like *Centrolophus*, are known from single examples only. Their development, as well as that of many of the more common forms which spawn in the open or deep sea, is perfectly unknown.

In seeking information concerning this part of the British fauna, we are not hunting after a shadow: there is evidence enough to show that the depths of the British seas are inhabited by a fish-fauna very different from that of the coasts, and that this fauna is composed of two elements—first, of those which may be regarded as indigenous, and, secondly, of such forms as are frequently, perhaps constantly, carried by currents from more southern parts of the Atlantic northwards, even to the coasts of Norway (*Antennarius, Batrachus, Beryx*)—not to mention those fishes which by their strong power of swimming are enabled to reach our shores in their migrations, as *Ausonia*.

The causes of our incomplete knowledge of these fishes are evident: zoologists were either not aware of the existence of such a fauna, or satisfied with the stray specimens thrown in their way by accident; while the difficulties surrounding the examination of the deep-sea fishes are so great as to render all progress in attaining to a knowledge of them extremely slow. Still it may be hoped that, after the attention of naturalists has been directed to the subject, no opportunity will be lost of advancing it.

Such an opportunity occurred to Mr. J. Gwyn Jeffreys, who, during his exploration of the marine invertebrate fauna of the Shetland Islands, preserved the specimens of fishes which were brought up in the dredge from a depth of from 80 to 90 fathoms. Small as the number of specimens is, the result of their examination proved to be most interesting and satisfactory, inasmuch as they belong to four species new to the British fauna, two being new to science, viz. *Ammodytes siculus* (Swains.), *Motella macrophthalma* (sp. n.), *Callionymus maculatus* (Bonap.), and *Gobius Jeffreysii* (sp. n.). On former occasions I have pointed out that the geographical range of deep-sea fishes appears to be extended in proportion to the vertical depth inhabited by them, and that they are either distinguished by an increased size of the eye to collect as many rays of light as possible, or by a rudimentary condition of that organ, as is the case with fishes inhabiting caves. This is in some measure verified by the species collected by Mr. Jeffreys, which, however, it must be remembered, inhabit a much less depth than *Regalecus*, *Plagyodus*, &c. Two of them (*Callionymus maculatus* and *Ammodytes siculus*) were previously known as occurring in the Mediterranean; and the eyes of three of them are conspicuously larger than in their congeners (*Ammodytes lancea, Callionymus lyra,* and *Motella tricirrata*).

1. *Ammodytes siculus* (Swains.).

(Smooth Sand-Launce.)

This species was hitherto known from Sicily only. For description see Günth. Fish. iv. p. 386.

2. *Motella macrophthalma.*

(Large-eyed Rockling.)

Günth. Ann. & Mag. Nat. Hist. 1867, vol. xx. p. 290, pl. 5. fig. B.

This species has three barbels, one at each of the anterior nostrils and one at the chin. It is distinguished from specimens of the same size of the other three-bearded species by its large eye, the diameter of which, in the specimen obtained, is as long as the snout, one-fourth of the length of the head, and much longer than the width of the interorbital space. The teeth of the mandible are very unequal in size, some being canine-like. The anterior ray of the rudimentary first dorsal fin is about as long as the eye. D. 55. A. 55. Back with narrow brownish cross bars.

Three inches long.

The figure quoted represents the specimen of the natural size. For the sake of comparison the figure of the head of *Motella tricirrata* (B′) has been added.

3. *Callionymus maculatus*, Bonap.

(The Southern Dragonet.)

Günth. *l. c.* p. 290, pl. 5. fig. A.

This species is common in the Mediterranean; but it has been also observed on the coast of Norway. It is easily recognized by the shortness of the snout relatively to the diameter of the eye.

4. *Gobius Jeffreysii.*

D. 6 | 10. A. 9. L. lat. 30.

Günth. *l. c.* p. 290, pl. 5. fig. C.

Body as deep as broad anteriorly, its greatest depth being one half of the length of the head, which is two-sevenths of the total (without caudal). Head depressed, broader than high, its greatest width being two-thirds of its length. Snout of moderate extent, though shorter than the eye; lower jaw

projecting beyond the upper. Eyes very close together, large, their diameter being two-sevenths of the length of the head. Dorsal fins higher than the body; the second dorsal spine more or less prolonged. The pectoral and ventral fins reach equally far backwards, to the vent. A series of five rounded blackish spots along the lateral line, the last being on the root of the caudal fin. Dorsal fins with series of black spots; outer half of the anal blackish. A blackish bar below the eye.

Three specimens, two inches long.

The only British species with which this Goby might be confounded, and to which it is evidently allied, is *Gobius rhodopterus* (Gthr.); however, this latter species is said to have the interorbital space broader, its width being equal to one half of the diameter of the eye (Cuv. & Val. xii. p. 50); and M'Coy, who examined two Irish examples, describes the snout as "very short, tumid, and convex," which character cannot be applied to *G. Jeffreysii.*

Second Report of the Rainfall Committee, consisting of J. GLAISHER, *F.R.S.*, Lord WROTTESLEY, *F.R.S.*, Prof. PHILLIPS, *F.R.S.*, J. F. BATEMAN, *F.R.S.*, R. W. MYLNE, *F.R.S.*, C. BROOKE, *F.R.S.*, T. HAWKSLEY, *C.E.*, *and* G. J. SYMONS, *Secretary.*

YOUR Committee consider it will be convenient that the present Report should be so arranged as readily to compare with the previous one; the different branches of rainfall investigation are therefore classed under the same headings as in the last Report, and new branches are noticed subsequently.

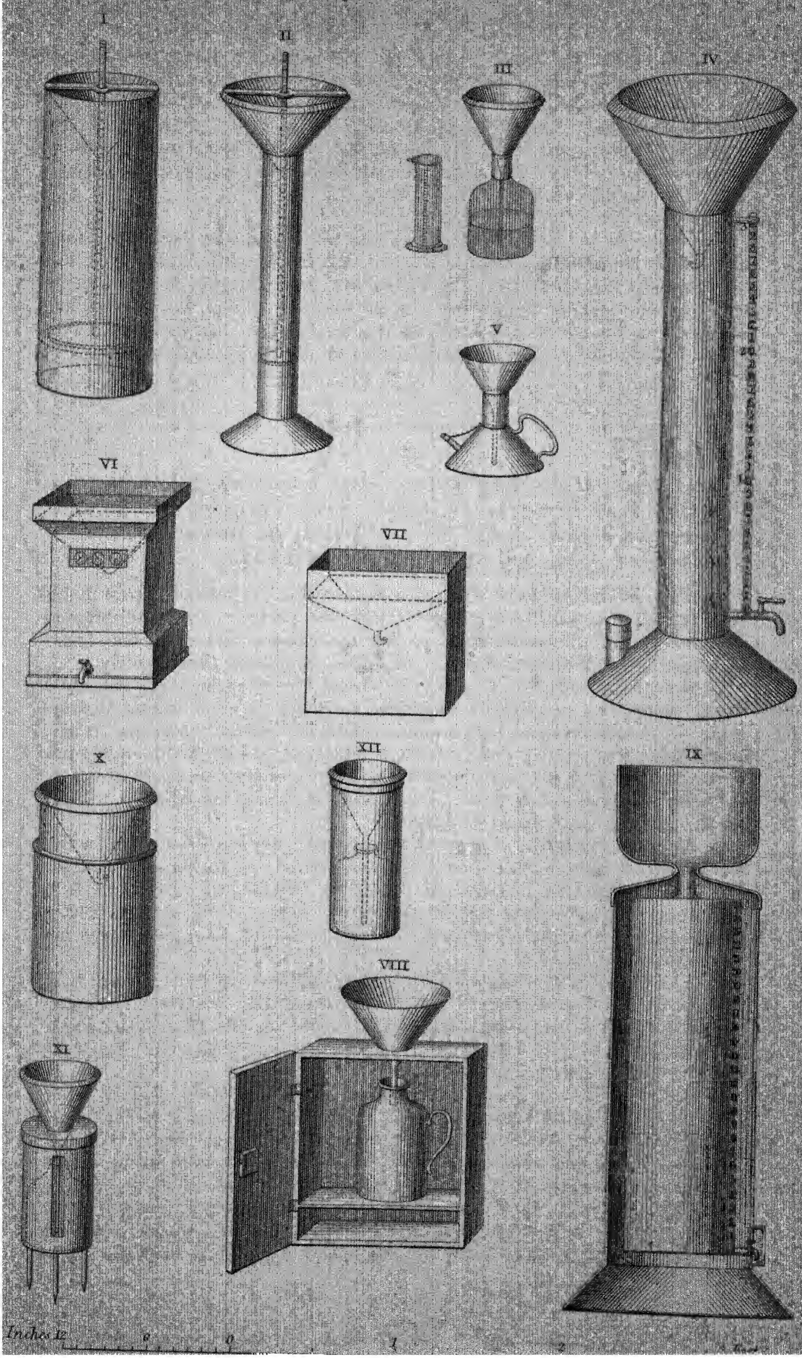
1. *Extraction and Classification of published Records.*—This very important work, which was temporarily suspended to allow of more urgent matters being pressed on, has now been resumed, and will be steadily pursued; it may be desirable to state that its completion must not be expected for some few years; the labour involved is excessive, but time and perseverance will ensure the accomplishment of the work, a work not for present use alone, but of the greatest service to all future inquirers.

2. *Examination of Rain-gauges.*—Steady progress has been made in this matter, Mr. Symons having during the year visited and tested sixty gauges; full details of the examinations are annexed to this Report. By reference to the list of stations in the British Association Report, 1865, pp. 192–242, it will be seen that nearly every gauge in the counties of Kent and Sussex has been visited and tested.

3. *Inclined and Tipping Funnelled Gauges.*—These instruments were fully described in the last Report; Mr. Chrimes, who kindly undertook the entire cost of the erection and maintenance of these instruments, has continued the observations, which it affords us much pleasure to state will shortly be examined by Professor Phillips.

4. *Influence of River Mists on the Amount of Rain collected.*—This question remains exactly in the same position as at the time of our last Report, since the following suggestion, thrown out by Mr. Symons in "British Rainfall, 1866," p. 7, has met with no response, "I feel rather beaten by these difficulties, and do not see how to solve the original proposition of determining the influence of river mists on the amount of rain collected, unless it be by transferring the Shepperton gauges to some flat dry district, tolerably uniform in its level, with a large piece of ornamental water, and then the gauge

Rain gauges in use in 1866.



might either be placed on an island, if free from trees, or float moored in the centre of a pond or lake. If any observer can offer these conditions, I shall gladly place the instruments at his service, as the expediency of continuing them in their present state seems doubtful."

5. *Additional Rain-gauges in Derbyshire.*—The remarkable geological formation of this beautiful county has specially marked it out as a field of rainfall research; some valuable but fragmentary observations were made by Mr. Bateman on the rainfall in the neighbourhood of the Peak, and observations have long been taken at Combs Moss, Chapel-en-le-Frith, Woodhead, and other stations in the N.W. of the county; from 1761 to 1813 a very regular record was kept at Chatsworth; for a quarter of a century Mr. Davis has been observing with great care at Derby, having been preceded in the same town by Mr. Swanwick, who also observed for twenty-five years at the beginning of the century. From this it may be inferred that the mean fall, and the secular variation of annual fall, at certain points in the county are pretty well determined; but hitherto we have had little or no information as to the relative fall in different parts of the county, and specially in that most interesting district which lies between Ambergate and Rowsley, having Matlock for its centre. Cordially assisted by the Hon. and Rev. O. W. Forester, the Rev. J. M. Mello, and Mr. Davis of Derby, we have the pleasure of noticing considerable progress in the investigation of this question. There are still deficiencies in some parts of the county which we purpose bringing before the residents so as to render the cordon of stations complete.

6. *Additional Gauges in the Lake-district.*—The erection of any more rain-gauges in the English Lakes may at first sight appear superfluous and undesirable, but a little explanation will, we think, convince all that their organization by Mr. Symons is a most important step in rainfall work. Up to 1844 we believe no greater annual fall than 90 inches had been recorded in any part of the British Isles. Dr. Miller, of Whitehaven, planted a gauge at Ennerdale Lake in November 1843, and yearly increased and varied his stations until the fall in the valleys of Wastdale and Borrowdale, and "Seathwaite" and "The Stye," became with meteorologists as well known as London or Dundee. In 1853 these were all discontinued, save those in charge of Mr. Dixon at Seathwaite and the Stye. In 1864 Isaac Fletcher, Esq., F.R.S., of Tarn Bank, reorganized the stations in these valleys, while some of the other valleys were taken charge of by other observers; this being the condition of affairs in Cumberland, and Captain Mathew having at the same time undertaken to investigate the fall of rain in the Snowdonian range, Mr. Symons felt that this was an especially eligible time for examining if the remarkable falls* so clearly proved to exist in the vicinity of Scawfell extend far therefrom; and for this purpose he devoted nearly two months last autumn to personally superintending the erection of gauges in parts of the Lake-district far removed from the sites of the other gauges, out of the ordinary routes of tourists, and, as some would have thought, out of the district of remarkable rains. The results of these observations will be fully noticed in our next Report.

7. *Percentage of Annual Rain which falls Monthly in different localities.*—Under the head of "*Extraction and Classification of published Records,*" we have explained that all available returns of the fall of rain at any time, and in any part of the British Isles, are being carefully collected. These returns are tabulated on sheets, whereof a facsimile is appended to this Report, and

* In 1866 the enormous fall of 225 inches was measured at the Stye.

of which about 300 are perfectly filled, as is Table I., and between 4000 and 5000 are in process of filling. It must not be supposed that this large

Table I.

RAINFALL AT KENDAL.

Observer, *S. Marshall, Esq.* Authority, *MS. Return.*

Rain-gauge. { By *Mr. Marshall.* Diameter, 8 in. Height above Ground, 4 ft. 6 in. Above Mean Sea-level, 149 ft.

Year	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	Means.
January ...	·43	1·62	2·28	1·63	14·76	5·35	3·94	3·43	1·71	5·32	4·047
February ...	4·77	8 21	4·26	4·58	5·72	8·82	3·92	5·84	1·01	5·74	5·287
March......	5·05	6·03	3·55	2·07	5·17	5·05	6·34	1·98	4·00	6·07	4·531
April	5·66	2·44	2·23	3·75	1·04	1·59	2·84	1·61	2·95	1·26	2·537
May	2·83	·72	1·60	2·53	1·64	3·06	·05	1·20	2·13	·71	1·647
June	5·29	2·68	4·64	7·72	6·70	1·25	8·00	3·61	2·89	3·10	4·588
July	4·96	4·08	2·64	2·23	5 05	6·26	9 05	4·73	6·07	8·46	5·353
August ..	4·22	3·90	4·43	1·97	6·17	3·11	3·76	3·11	7·63	7·28	4·558
September.	8·03	6·39	2·30	3·53	4·91	7·81	5·90	4·18	2·71	7·44	5·320
October ...	4·69	11·81	8·35	3·75	4·72	4·39	3·97	5·32	7·03	3·30	5·733
November .	10·02	8·56	5·37	7·44	4·21	6·31	8·01	6·18	4·03	4·35	6·448
December ..	2·08	4·98	8 04	14·22	5·05	2·89	8·55	7·20	3 58	4·94	6·153
Totals ..	58·03	61·42	49·69	55·42	65·14	55·89	64·33	48·39	45·74	57·97	56·202

proportion of incomplete sheets implies imperfect registers, such is not the case; the appearance depends on the fact that, for facility of reference and entry, it was necessary to make all the forms commence with some uniform date, and as the observations were of course commenced in various years, there thus (temporarily) appear to be far more fragmentary registers than there really are. The register sheets, it will be seen, are to a considerable extent self-proving, while the decennial period possesses advantages which are self-evident. These sheets form the basis of the investigation now to be described. It will be seen that the last column in the register sheet gives the mean fall in the month and in the year; the former divided by the latter (the decimal being of course shifted) gives the percentage, of the yearly amount, which fell in each month. The computations are at present only

Table II.—Monthly Percentage of Mean Annual Rainfall, England, in the years 1850–59.

Mean Annual Fall from	15 in. to 20 in.	20 in. to 25 in.	25 in. to 30 in.	30 in. to 35 in.	35 in. to 40 in.	40 in. to 45 in.	45 in. to 50 in.	50 in. to 60 in.	Above 60 in.	Mean of all Stations.
January ...	7·7	8·0	8·8	9·4	10·3	11·4	9·3	11·8	14·0	10·08
February ..	4·7	4·9	5·0	5·9	6·5	7·3	7·7	7·3	9·4	6·52
March .	5·3	5·2	5·4	5·7	6·6	6·6	5·3	6·1	5·9	5·79
April	6·9	7·1	7·2	7·2	6·9	6·8	5·6	6·5	5·6	6·64
May	7·3	7·9	7·5	6·4	6 0	5·9	4·9	5·5	4·1	6·17
June	8·7	9·1	8·1	8·3	8·4	7·7	9·4	7·5	6·4	8·18
July	12·4	11·6	10·2	8·7	8·3	7·7	9·4	7·7	7·0	9·22
August .	11·8	10·6	9·6	9·3	8·9	8·6	10·9	8·8	9·1	9·73
September.	9·3	9·0	8·9	8·8	8·3	7·6	8·6	8·1	7·1	8·41
October ..	10·7	11·8	12·6	12·1	11·8	10·9	10·9	10·7	9·9	11·27
November.	8·9	8·5	9·0	9·1	8·8	9·2	8·7	9·0	8·9	8·89
December..	6·3	6·3	7·7	9·1	9·2	10·3	9·3	11·0	12·6	9·10
Stations ...	4	29	28	10	6	4	2	3	3	89

complete for England and for the ten years 1850–59 inclusive. The results are so striking and seem likely to have such an important bearing on questions of water supply, and (probably to a less extent) on agricultural matters, that we think it would be wrong to suppress them because we hope to report fully on the subject next year, and that we shall best discharge our duty by reporting the facts which have been ascertained, but prefixing the caution that although these deductions are based on daily observations for ten years at each of ninety stations, yet that this apparently firm basis is by no means unassailable; the laws that hold good in one ten years may not be so markedly confirmed by other ten years, and those which hold south of the Tweed may be reversed or modified in the sister countries. Table II. indicates the results at present obtained.

8. *Approximate Determination of the Height of Rain-gauge Stations above Sea-level.*—There having been very many stations (perhaps 500 out of a total of 1500) the altitude of which above the mean level of the sea was unknown, considerable attention has been given to the determination of this important element. Before noticing the steps we have recently taken, it may be well to state briefly what is meant by the apparently simple term "height above mean sea-level," and to what extent this information is obtainable. "Mean sea-level," otherwise called "Ordnance Datum," is the mean height of the sea as recorded by the tide-gauge erected at Liverpool by the Ordnance Survey Department, and *it* is the zero from which all their altitudes are measured. The altitudes determined by the Ordnance Department have been published in two forms—(1) in works entitled "Abstracts of Spirit Levelling in England and Wales, Scotland and Ireland," wherein, as the title implies, are given the heights of certain marks, called Benchmarks, (/|\) cut on milestones and other permanent objects along some of the principal roads in the British Isles; (2) in the maps on the 6-inch (and now on some of the 1-inch) scale the altitude of many points are given, and contour lines are also marked. This excellent system being in operation, it may be asked why this Committee have done anything in the matter; the reply is very simple and, we think, conclusive. We have not attempted in any way to supplant or encroach on the functions of the Ordnance Department; but we have called the attention of our observers to the benefit derivable from levelling to the nearest marks, sometimes on their own lodge-gates, yet unknown to them. In this way we have endeavoured to popularize and extend the benefits conferred by these government levels. But there are many places ten, fifteen, or more miles from the nearest benchmark, and for the benefit of observers thus situate, the following arrangements were made. Notice was sent to about 800 rainfall observers that they would be doing good service by taking careful readings of their barometers thrice daily (9 A.M., 3 P.M., and 9 P.M.) for ten days, May 24th to June 2nd, 1867, entering them on a printed form sent with the notice, and when filled returning the same to Mr. Symons. These documents were then sorted into two groups, the one comprising only returns from stations at which the index-error of the barometer and its height above the mean level of the sea were known, and the other group comprising those stations of which the height was unknown. The returns having been carefully cleared of all errors, intercomparison of the ultimate results has given us a secondary series of altitudes probably correct to 10 or 20 feet, being accurate enough for all rainfall purposes, these being also available as primary stations should a repetition of the process be necessary at any future time.

EXAMINATION OF RAIN-GAUGES.

Reference number.	Date of examination.	County.	Name of station, owner, and observer.	Construction of gauge.	Maker's name.	Time of reading.	Height of gauge. Above ground.	Height of gauge. Above sea-level.	Diameters (those marked M = mean).	Equivalents of water. Scale-point.	Equivalents of water. Grains.	Error at scale-point, specified in previous column.	Remarks on position, &c.	Reference number.
	1866.						ft. in.	feet.	in.	in.				
167.	Aug. 16.	Cumberland	Borrowdale, Seathwaite, Mrs. Abberley.	III.	Potter	9 a.m.	1 0	422	5·04 4·96 5·02 5·00 M 5·005	·1 ·2 ·3 ·4 ·5	510 1020 1500 1950 2480	−·002 −·005 −·002 −·007 −·001	Gauge was tested in 1862 (see No. 8) and the funnel remains unaltered; but the glass had been broken and a new one (rather incorrect) supplied. [This has been in turn supplanted by another perfectly accurate one.—Nov. 1866.]	167.
168.	Aug. 28.	Nottingham	Nottingham, Welford Bridge, R. W. Mylne, Esq.	X.	Negretti & Zambra	9 a.m.	0 4	90	8·00 8·00 7·98 8·00 M 7·995	·1 ·2 ·3 ·4 ·5	1260 2540 3790 5060 6350	+·001 correct +·001 +·001 +·001	In railed enclosure, about 3 ft. 6 in. high and 6 ft. square. Mr. Mylne ordered it to be cut down to 2 ft., the position will then be unexceptionable, just above the level of the highest floods in the Trent, from which it is only 200 yards distant.	168.
169.	Aug. 31.	Derby................	Chapel-en-le-Frith, M. S. & L. R.	VIII.	Casartelli	9 a.m.	2 6	965	8·48 8·49 8·50 8·48 M 8·488	·1 ·2 ·3 ·4	1460 2870 4280 5630	−·002 −·001 correct +·006	Clear open position, on the slope of a hill just above the top of the inclined plane.	169.
170.	Sept. 18.	Cumberland	Derwent Island, H. C. Marshall, Esq.	III	Casella	9 a.m.	1 0	240	5·02 4·98 5·01 5·00 M 5·003	·1 ·2 ·3 ·4 ·5	496 990 1500 1990 2480	correct +·001 −·002 −·001 correct	The island is so thickly wooded no very open spot can be found; when visited there were some flowers 3 ft. high, 2 ft. S.E. of the gauge, and a tree 60 ft. high about 40 ft. S.W.; the results are checked by No. 171.	170.
171.	Sept. 18.	Cumberland	Keswick, Crow Park, H. C. Marshall, Esq.	XII.	Casella	monthly.	1 9	260	6·95 7·00 7·02 6·97 M 6·985	·1 ·2 ·3 ·4 ·5	1010 2000 3000 3950 4950	−·004 −·007 −·010 −·008 −·011	On the circular knoll, formerly known as the racecourse an exposed position quite clear of trees. A number IX. gauge is in the same railed enclosure with this gauge, and both are read.	171.
172.	Sept. 19.	Cumberland	Borrowdale, Seathwaite, I. Fletcher, Esq., F.R.S., Mrs. Abberley.	See page 466.	Cooke..............	monthly.	0 8	422	4·03 4·03 4·03 4·02 M 4·027	·1 ·5 1·0	320 1585 3160	+·001 +·008 +·018	Placed close to No. 8 for comparison therewith. Gauge identical with those placed by Mr. Fletcher at Scawfell Pike ... 3200 ft. | Sprinkling Tarn 1985 ft. Esk Hause ...... 2550 | Mosedale .... 624 Great End ...... 2982 | Styehead Tarn... 1472 Wasdale Head... 247 | The Stye .... 1077 Brant Rigg ...... 695 | Stonethwaite ... 330	2.
173.	Sept. 19.	Cumberland	Keswick, Greta Bank, T. S. Spedding, Esq.	III.	Dixey	....	0 6	377	5·04 5·02 5·03 5·05 M 5·035	·1 ·2 ·3 ·4 ·5	530 1050 1525 2010 2500	−·005 −·009 −·003 correct +·003	In flower-garden, and quite bedded in geraniums; asked that it might be moved to a clearer spot. There was also a tree 60 ft. high about 40 ft. distant in E.	173.
174.	Sept. 24.	Westmoreland ...	Patterdale, W. Marshall, Esq. ...	XII.	Casella	weekly.	1 6	490	7·00 6·99 7·01 7·00 M 7·000	·1 ·2 ·3 ·4 ·5	1000 1950 3000 3900 4900	−·003 −·001 −·009 −·001 −·004	In railed enclosure in a field at the head of Ullswater, a capital open position. A number IX. gauge has been in the same enclosure for some years, but I could not learn how long it had been given up; it was not in use when visited.	174.
175.	Sept. 24.	Westmoreland ...	Greenside, Stang End, W. Marshall, Esq., J. Barningham.	XII.	Casella	9 a.m.	....	1550	7·03 6·97 7·01 6·99 M 7·000	·05 ·10 ·20 ·25 ·50	580 1090 2000 2500 4900	−·010 −·012 −·006 −·007 −·004	On a shelf-like ledge of rock, quite overhung by other rocks; a bad position. Scale-point equivalents not certain; it was raining hard and blowing a gale, so that it was not easy to hold	175.

EXAMINATION OF RAIN-GAUGES (*continued*).

Reference number.	Date of examination.	County.	Name of station, owner, and observer.	Construction of gauge.	Maker's name.	Time of reading.	Height of gauge. Above ground.	Height of gauge. Above sea-level.	Diameters (those marked M = mean).	Equivalents of water. Scale-point.	Equivalents of water. Grains.	Error at scale-point, specified in previous column.	Remarks on position, &c.	Reference number.
	1866.						ft. in.	feet.	in.	in.				
													the glasses steady, and there was nothing to set them down upon.	
76.	Sept. 25.	Cumberland	Ullswater, Hallsteads, A. Marshall, Esq.	IX.	Marshall & Co. ...	monthly.	4 6	490	9·99 10·00 10·00 10·02 M 10·002	....	....	....	In a large open field, railed in and in all respects well placed.	176.
77.	Sept. 26.	Cumberland	Ullswater, Watermillock, W. Marshall, Esq.	IX.	Marshall & Co. ...	monthly.	4 8	720	10·02 10·00 9·98 10·00 M 10·00	....	....	....	In garden S.E. of the house and sufficiently exposed. A few trees, but not high ones.	177.
78.	Oct. 5.	Westmoreland ..	Ambleside, Loughrigg, E. B. W. Balme, Esq.	X.	Negretti & Zambra	9 a.m.	0 6	553	7·97 8·01 8·02 8·00 M 8·000	·1 ·2 ·3 ·4 ·5	1300 2620 3800 5080 6370	−·002 −·006 +·001 correct −·002	On the lawn quite exposed. The position is somewhat unusual, the hill dropping rapidly to E., W., and S. from the small plateau on which the gauge is placed.	178.
79.	Oct. 5.	Lancashire.........	Coniston, R. J. Bywater, Esq.	XI.	Negretti & Zambra	....	1 0	287	4·98 5·03 5·00 5·02 M 5·007	·01 ·10 ·20 ·30 ·40 ·50	50 500 1000 1490 1980 2480	correct −·001 −·001 correct +·002 +·001	On edge of lawn, east side of Coniston Water, about one mile from its head. Ground rises gently to the east of the gauge. No trees near.	179.
80.	Oct. 8.	Westmoreland ...	Troutbeck, The Howe, Admiral Wilson.	VIII.	Marshall, Kendal	....	1 6	470	8·03 7·99 8·00 7·97 M 7·998	·01 ·1 ·2 ·3	110 1254 2520 3800	+·001 +·001 +·001 correct	On the south side of the valley, ¼ of a mile W. of Troutbeck Church; the house is 40 or 50 ft. S. of the gauge, which is on the lawn sloping to the beck.	180.
81.	Oct. 16.	Westmoreland ...	Lowther Castle, Earl Lonsdale.	X.	Pastorelli	9 a.m. & 9 p.m.	3 6	810	8·02 8·03 7·97 7·94 M 7·990	·1 ·2 ·3 ·4 ·5	1290 2560 3880 5100 6430	−·002 −·002 −·006 −·003 −·008	On a post in the kitchen-garden, clear of obstructions, save perhaps a few trees. There was no inside can to this gauge, and the water running about the large vessel would doubtless be always diminished by evaporation and the difficulty of pouring out without occasional spilling.	181.
182.	Oct. 18.	York	York, Coney Street, Mr. Sigsworth.	III.	Cooke...............	9 a.m.	7 0	40	4·98 5·05 5·01 4·97 M 5·003	·1 ·2 ·3 ·4 ·5	500 1000 1490 1990 2490	−·001 −·001 correct −·001 −·002	Gauge fastened to a wall close to, and 30 ft. above, the river Ouse. Rather sheltered in the N. by the houses.	182.
183.	Oct. 18.	Westmoreland ...	Penrith, Great Strickland, H. H. Plummer, Esq.	XI.	Negretti & Zambra	....	1 0	650	5·03 4·98 5·02 5·00 M 5·008	·1 ·2 ·3 ·4 ·5	500 1000 1490 1980 2490	−·001 −·001 correct +·002 −·001	Gauge on lawn well placed, and clear of all obstacles.	183.
184.	Oct. 19.	Westmoreland ...	Penrith, Brougham Hall, Lord Brougham, Mr. Campbell.	II.	....	....	4 6	418	12·00 12·08 12·02 12·10 M 12·005	....	....	....	The diameter of lesser tube at top was 4·04 in., and the scale (where perfect) gave about 11·3 in. for each in., therefore the gauge was probably correct when new, but it is very old, and the cylinder has been repeatedly burst by frost and soldered up again; the rod has also been broken and spliced,	184.

EXAMINATION OF RAIN-GAUGES (*continued*).

Reference number.	Date of examination.	County.	Name of station, owner, and observer.	Construction of gauge.	Maker's name.	Time of reading.	Height of gauge. Above ground.	Height of gauge. Above sea-level.	Diameters (those marked M = mean).	Equivalents of water. Scale-point.	Equivalents of water. Grains.	Error at scale-point, specified in previous column.	Remarks on position, &c.	Reference number.
	1866.						ft. in.	feet.	in.	in.			and fresh floats have been added from time to time. I recommended that a new one should be placed near it, and the result is that the old one records *nearly* 25 *per cent. too little.*	
185.	Oct. 20.	Cumberland	Penrith, Edenhall, Mr. Bowstead.	III.	Newcomb	....	0 10	320?	4·99 4·98 5·00 5·01 M 4·995	·1 ·2 ·3 ·4 ·5	500 1000 1490 1980 2480	—·001 —·002 —·001 correct —·001	Sheltered on the E. by a row of elms about 35 ft. distant, and perhaps 50 ft. high. All else clear.	185.
186.	Dec. 4.	Sussex	Buxted Park, Col. Harcourt, Mr. Huggate.	IV.	Dixey	9 a.m.	3 0	104	11·22 11·25 11·00 11·32 M 11·198	·09 ·18 ·27	2500 5000 7500	—·011 —·021 —·031	Good position in kitchen-garden. When visited, was found on a pedestal, so that the funnel was 6 ft. above the ground, from which pedestal it had more than once been blown down; suggested that it should be placed on the ground; agreed to.	186.
187.	Dec. 4.	Sussex	Uckfield Observatory, C. L. Prince, Esq.	IV.	Dixey	9 a.m.	6 0	149	11·25 11·21 11·28 11·20 M 11·235	·10 ·20 ·25	2500 5000 6250	correct correct correct	Good position, in centre of town. Gauge on a pedestal like No. 186, but securely fastened. Would be rather sheltered if lower.	187.
188.	Dec. 6.	Sussex	Maresfield, Forest Lodge, Capt. Noble.	X.	Negretti & Zambra	....	1 2	263	7·99 8·00 8·00 8·02 M 8·002	·1 ·2 ·3 ·4 ·5	1290 2550 3850 5100 6390	—·002 —·001 —·003 —·002 —·003	In a railed enclosure around the Observatory, the nearest angle of which is only 7 ft. distant in N.W. and 14 ft. high.	188.
189.	Dec. 6.	Sussex	Maresfield, The Rectory, Rev. E. Turner.	X.	Negretti & Zambra	9 a.m.	1 3	172	7·97 7·93 7·98 7·93 M 7·953	·1 ·2 ·3 ·5	1260 2510 3740 6320	correct correct +·002 —·004	On lawn, rather sheltered by shrubs in S. and S.S.W., about 6 ft. high and 6 ft. distant.	189.
190.	Dec. 7.	Sussex	Uckfield, Moulsey Gore, F. Brodie, Esq.	X.	Negretti & Zambra	9 a.m.	0 6	112	7·98 8·02 8·03 7·98 M 8·003	·1 ·2 ·3 ·4 ·5	1300 2620 3800 5010 6280	—·002 —·006 +·001 +·006 +·006	Very near to No. 187, in an open field nearer to the railway.	190.
191.	Dec. 7.	Sussex	Newick, Ketches, Miss Shifner ...	X.	Negretti & Zambra	9 a.m.	0 8	192	8·03 8·03 7·97 7·98 M 8·002	·1 ·2 ·3 ·4 ·5	1330 2550 3900 5080 6360	—·005 —·001 —·007 correct —·001	On lawn, clear of trees, and with a level tract for some distance round.	191.
192.	Dec. 7.	Sussex	Newick, Beechlands, W. Blaaw, Esq.	III.	Casella	9 a.m.	0 10	210	4·98 5·03 5·00 5·00 M 5·003	·1 ·2 ·3 ·4 ·5	510 1030 1490 2000 2500	—·003 —·007 correct —·003 —·004	In a sunk garden, surrounded by hedges and the house and trees, but none are very close.	192.
193.	1867. May 29.	Sussex	Pevensey, M. Vidler, Esq.........	X.	Negretti & Zambra	9 a.m.	4 0	10	8·00 8·00 8·02 7·92 M 7·985	·1 ·2 ·3 ·4 ·5	1300 2550 3800 5050 6300	—·003 —·002 —·001 +·001 +·002	On the beach, in a very exposed position. Gauge fastened to a short post, and enclosed by a palisade 6 ft. square and 3 ft. 6 in. high.	193.
194.	May 30.	Sussex	Beachy Head, Miss W. L. Hall.	XII.	Casella	monthly.	1 4	570	4·99 4·99	....	....	....	On the top of Beachy Head, about 100 yards W. of the Coast-guard	194.

EXAMINATION OF RAIN-GAUGES (*continued*).

Reference number.	Date of examination.	County.	Name of station, owner, and observer.	Construction of gauge.	Maker's name.	Time of reading.	Height of gauge. Above ground.	Height of gauge. Above sea-level.	Diameters (those marked M = mean).	Equivalents of water. Scale-point.	Equivalents of water. Grains.	Error at scale-point, specified in previous column.	Remarks on position, &c.	Reference number.
	1867.						ft. in.	feet.	in.	in.				
									4·97 5·02 M 4·993				station, and under the care of the men on duty. Glass believed to be the same as No. 196; if so, gauge must be practically correct.	
195.	May 31.	Sussex	Lewes, Glynde Place, Mr. M'Leod.	III.	Bate, Poultry ...	9 a.m.	3 0	59	5·00 5·00 5·02 4·98 M 5·000	·1 ·2 ·3 ·4 ·5	500 1020 1540 2020 2510	−·001 −·006 −·011 −·007 −·006	On a post in kitchen-garden, an espalier 5 ft. high 4 ft. off in N.E., N., and N.W., all else clear; suggested removal to a more open spot: found observer's books badly cast, checked them all through, and took copies.	195.
196.	May 31.	Sussex	Eastbourne, Miss W. L. Hall ...	XII.	Casella	....	4 3	30	4·98 4·99 5·02 4·99 M 4·995	·1 ·2 ·3 ·4 ·5	500 1000 1480 1980 2470	−·001 −·002 +·001 correct +·001	In the best practicable position in a rather sheltered garden; probably nothing is more than 45° above the gauge, and the results may be accepted.	196.
197.	June 1.	Sussex	Brighton, Upper Brunswick Place, Dr. Kebbel.	VII.	....	....	2 6	45	10·10 10·00 10·05 10·05 M 10·050	....	....	....	No use at all. The gauge was right underneath a sycamore tree, in most ridiculous proximity to the stem. No further observations will be made.	197.
198.	June 1.	Sussex	Brighton Water-works, W. Blaber, Esq.	VI.	Crosley	....	5 6	90	10·00 10·00 10·00 M 10·000	·09	2525	−·010	In a capital position on the large lawn of the water-works.	198.
199.	June 1.	Sussex	Brighton Water-works, W. Blaber, Esq.	XII.	Casella	....	0 7	90	5·00 5·00 4·99 M 4·997	·01 ·10 ·20 ·30 ·40 ·50	50 500 1000 1490 1980 2480	correct −·001 −·002 −·001 correct −·001	Near to No. 198, and in an equally good position.	199.
200.	June 1.	Sussex	Brighton, Richmond Terrace, O. Smith, Esq.	XII.	Private	....	3 0	58	6·20 6·20 6·20 6·20 M 6·200	·3 ·6 ·9 1·2	2500 5000 7500 10000	−·028 −·056 −·084 −·112	Clear position, gauge (as usual with privately made ones) very incorrect. Returns have never been published, except under a pseudonym in a local paper; hope they never will be.	200.
201.	June 1.	Sussex	Brighton, St. James Street, E. Rowley, Esq.	III.	....	9 a.m.	1 0	40	5·00 4·95 5·04 5·00 M 4·997	·1 ·3 ·4 ·5	500 1510 2000 2505	−·001 −·005 −·004 −·006	Very much sheltered. Houses in N.W. 40 ft. high and 40 ft. off, and in S.E. 40 ft. high and 27 ft. off.	201.
202.	June 1.	Sussex	Brighton, Eaton Place, Dr. Barker.	X.	Browning	9 a.m.	0 3	98	8·00 8·00 7·95 8·04 M 7·998	·1 ·2 ·3 ·4 ·5	1300 2570 3800 5010 6300	−·002 −·003 correct +·005 +·004	Good position, except from S.W., where the house, 45 ft. high, is only 30 ft. distant.	202.
203.	June 1.	Sussex	Brighton Gas-works...............	VI.	Crosley	....	4 0	72	10·00 9·98 10·02 M 10·000	....	....	....	On a post in a good open position.	203.
204.	June 8.	Kent	Beckenham, C. O. F. Cator, Esq.	X.	Negretti & Zambra	9 a.m.	0 6	142	8·01 7·97 7·97 7·96 M 7·977	·1 ·2 ·3 ·4 ·5	1240 2525 3810 5050 6305	+·002 correct −·002 correct	On lawn, rather near its sloping edge, but otherwise unexceptionable position.	204.

EXAMINATION OF RAIN-GAUGES (*continued*).

Reference number.	Date of examination.	County.	Name of station, owner, and observer.	Construction of gauge.	Maker's name.	Time of reading.	Height of gauge. Above ground.	Height of gauge. Above sea-level.	Diameters (those marked M = mean).	Equivalents of water. Scale-point.	Equivalents of water. Grains.	Error at scale-point, specified in previous column.	Remarks on position, &c.	Reference number.
	1867.						ft. in.	feet.	in.	in.				
205.	June 8.	Kent	Beckenham, C. O. F. Cator, Esq.	XII.	Apps	....	0 6	142	5·00 4·99 4·98 5·01 M 4·995	·1 ·2 ·3 ·4 ·5	500 1000 1500 1990 2490	−·001 −·002 −·003 −·002 −·003	Close to No. 204.	205.
206.	June 10.	Sussex	Farnhurst, Hawksfold, Miss E. A. Salvin.	X.	Negretti & Zambra	9 a.m.	1 0	....	8·03 8·00 7·98 7·99 M 8·000	·1 ·2 ·3 ·4 ·5	1300 2600 3950 5200 6600	−·002 −·005 −·011 −·010 −·020	On lawn facing S.W., and quite open, rather high ground overlooking Midhurst, &c.	206.
207.	June 10.	Surrey	Guildford, Commercial Road, Capt. James, R.E.	XI.	Negretti & Zambra	9 a.m.	1 0	120	4·98 5·03 5·02 5·01 M 5·010	....	....	....	In an open garden, a very good position. Equivalents not entered on the examination form, but think the glass *was* tested and found correct.	207.
208.	June 10.	Surrey	Guildford School, Dr. Merriman.	XI.	Negretti & Zambra	....	1 4	200	5·00 5·01 4·99 5·00 M 5·000	·1 ·3 ·4 ·5	496 1490 1985 2500	correct. −·001 correct. −·004	On lawn in a very good position.	208.
209.	June 11.	Sussex	Chichester, Chilgrove, W. L. Woods, Esq.	III.	Knight	9 a.m.	0 8	....	5·00 4·98 4·97 4·97 M 4·980	·1 ·2 ·3 ·4 ·5	500 1020 1520 2010 2500	−·002 −·007 −·009 −·009 −·008	Very good position; bottle neck rather small, and funnel therefore shaky. Rim of gauge rather flat, which will probably correct the errors of the glass.	209.
210.	June 11.	Sussex	Chilgrove, Bepton Hill, W. L. Woods, Esq.	III.	Knight	monthly.	0 6	....	5·00 4·99 5·00 5·00 M 4·998	·1 ·2 ·3 ·4 ·5	510 1010 1500 2000 2490	−·003 −·004 −·003 −·004 −·003	Quite open, in a hollow near the top of the hill, on the east side, but about 200 ft. below it.	210.
211.	June 11.	Sussex	Chichester Infirmary, W. Hills, Esq.	III.	Knight	....	1 0	50	4·95 5·03 5·02 5·00 M 5·000	·1 ·2 ·3 ·4 ·5	500 1000 1500 1980 2480	−·001 −·002 −·003 +·001 correct.	Has usually been in an open part of the lawn in front of the Infirmary, and will be replaced there as soon as alterations, in progress at time of visit, are completed. Gauge was temporarily carefully placed in a tolerably good position.	211.
212.	June 11.	Sussex	Chichester, West Dean, H. Paxton, Esq.	X.	Negretti & Zambra	....	1 3	250	8·02 7·98 8·00 8·01 M 8·003	·1 ·2 ·3 ·4	1300 2550 3780 5050	−·002 −·001 +·002 +·003	On the slope of the valley facing S.E., not very far from the Church; fairly exposed.	212.
213.	June 12.	Sussex	Chichester, West Gate, Dr. Tyacke.	III.	Knight	9 a.m.	0 6	40	4·92 5·09 5·10 5·00 M 5·028	·1 ·2 ·3 ·4 ·5	530 1040 1540 2040 2540	−·006 −·007 −·007 −·007 −·007	In a very open position, on a large level lawn.	213.
214.	June 14.	Sussex	Chichester, Shopwyke House, Rev. G. H. Woods.	X.	Negretti & Zambra	monthly.	1 3	61	8·00 7·98 8·02 8·00 M 8·000	·1 ·2 ·3 ·4 ·5	1300 2600 3850 5050 6300	−·002 −·005 −·003 +·002 +·004	In a large vase, on the lawn, good open position.	214.
215.	June 20.	Sussex	Bognor, Aldwick, Mr. Upton ...	III.	Knight	....	1 0	50	4·98 4·97	·1 ·2	500 1020	−·002 −·007	Found very close to a gooseberry-bush, had it moved to a clear spot.	215.

EXAMINATION OF RAIN-GAUGES (*continued*).

Reference number.	Date of examination.	County.	Name of station, owner, and observer.	Construction of gauge.	Maker's name.	Time of reading.	Height of gauge. Above ground.	Height of gauge. Above sea-level.	Diameters (those marked M = mean).	Equivalents of water. Scale-point.	Equivalents of water. Grains.	Error at scale-point, specified in previous column.	Remarks on position, &c.	Reference number.
	1867.						ft. in.	feet.	in.	in.				
									4·99 M 4·980 	·3 ·4 ·5	1540 2000 2510	−·013 −·007 −·010		
216.	June 21.	Sussex	Littlehampton, Yapton, R. Redford, Esq.	XII.	Casella		1 3	45	4·98 5·02 5·00 5·01 M 5·003	·1 ·2 ·3 ·4 ·5	500 1000 1490 1980 2480	−·001 −·001 correct. +·001 correct.	In a garden well exposed, clear level country.	216.
217.	June 24.	Sussex	Horsham, St. Leonards Lodge, W. E. Hubbard, Esq.	III.	Casella		1 6	301	5·00 5·00 5·00 5·00 M 5·000	·1 ·2 ·3 ·4 ·5	498 1000 1490 1975 2480	correct. −·002 −·001 +·002 correct.	At S.E. angle of a terrace, in a bed of cut heath; the gauge is 1 ft. 6 in. above the terrace, and about 6 ft. above the next lower one.	217.
218.	June 24.	Sussex	Horsham, St. Leonard's Lodge. The Gardens, Mr. S. Ford.	III.	Casella		1 6	273	4·98 5·02 5·00 5·00 M 5·000	·1 ·2 ·3 ·4 ·5	500 1000 1490 1980 2480	−·001 −·002 −·001 +·001 correct.	The house 30 ft. off in S.W. is about 25 ft. high, all else is clear. About a ¼ of a mile from No. 217.	218.
219.	June 24.	Sussex	Crawley, The Hyde, E. S. Biggs, Esq.	VIII.	Private		1 6	370	10·00 10·00 10·10 9·90 M 10·000	·1 ·2 ·3 ·4 ·5	1830 3690 5500 7450 9630	+·008 +·014 +·023 +·024 +·014	A very roughly made flat-funnelled gauge, placed about 4 ft. from the base of a large hot-house facing S. I have no doubt in rough weather both rain and snow unduly shoot into the gauge.	219.
220.	June 24.	Sussex	Petworth Rectory, Rev. C. Holland.	III.	Gould		1 6	170	5·06 5·06 5·06 5·03 M 5·053	·1 ·2 ·3 ·4 ·5	540 1040 1590 2100 2550	−·007 −·005 −·014 −·014 −·004	On lawn sloping to E., slightly but not injuriously sheltered.	220.
221.	June 25.	Sussex	Petworth Gardens, Mr. Jones	XII.	Casella		1 6	180	5·00 4·98 4·99 4·98 M 4·987	·1 ·2 ·3 ·4 ·5	500 1000 1490 1980 2480	−·001 −·003 −·002 −·001 −·003	In the kitchen-gardens, level, and very open position.	221.
222.	June 25.	Sussex	Arundel, Dale Park, J. C. Fletcher, Esq., Mr. Wilson.	IV.			3 0	316	11·22 11·18 11·23 11·14 M 11·193	·1 ·2 ·3 ·4 ·5	2600 5050 7580 9950 12950	−·005 −·003 −·005 −·001 −·021	In kitchen-gardens on slope to S., belt of trees in N., but not near enough to affect gauge. Rim of funnel very flat.	222.
223.	June 26.	Sussex	Worthing, Bedford Row, W. J. Harris, Esq.	XI.	Negretti & Zambra	9 a.m.	1 0	21	5·02 4·98 5·01 5·03 M 5·010	·09 ·2 ·3 ·4 ·5	500 1000 1490 1980 2480	−·010 −·001 +·001 +·002 +·002	In garden in front of Bedford Row, sheltered to the W. by houses 40 ft. high and 50 ft. distant.	223.
224.	June 26.	Sussex	Worthing, Dr. Barker	X.	Private	9 a.m.	1 0	18	13·2 13·2 12·9 13·2 M 13·125	·135 ·265 ·526 1·060	4376 8752 17504 35008	+·007 +·009 +·014 +·036	A very roughly made gauge, in an indifferent position.	224.
225.	June 27.	Sussex	Worthing, Findon, Rev. Dr. Cholmelly.	III.	Casella		1 0	167	5·02 4·80 5·00 5·00 M 4·98 ?	·1 ·2 ·3 ·4 ·5	510 1020 1500 2000 2510	−·004 −·007 −·005 −·007 −·010	Fair exposure on lawn, some elms, about 50 ft. high, 100 ft. distant in S.W. Gauge had been indented considerably at one point. The mean diameter as given is believed	225.

EXAMINATION OF RAIN-GAUGES (*continued*).

Reference number.	Date of examination.	County.	Name of station, owner, and observer.	Construction of gauge.	Maker's name.	Time of reading.	Height of gauge. Above ground.	Height of gauge. Above sea-level.	Diameters (that marked M = mean).	Equivalents of water. Scale-point.	Equivalents of water. Grains.	Error at scale-point, specified in previous column.	Remarks on position, &c.	Reference number.
	1867.						ft. in.	feet.	in.	in.			to indicate the true area of the gauge.	
226.	June 28.	Sussex	Steyning, Rev. H. Ingram	XII.	Casella	....	1 0	50	5·02 4·98 5·00 5·00 M 5·000	·1 ·2 ·3 ·4 ·5	500 1000 1500 2000 2500	−·001 −·002 −·003 −·004 −·004	Some trees in S.W., about 30 ft. off and 20 ft. high; the gauge is rather sheltered, but any injurious effect can hardly arise.	226.
227.	Sept. 13.	Forfar	Dundee, Eastern Cemetery, Mr. McKelvie.	I.	Adie	9 a.m.	0 4	164	3·00 3·00 3·00 3·00 M 3·000	1·30 1·00	2350 1800	−·016 −·008	In an open part of the Cemetery, which is on a very gentle slope towards the Tay.	227.
228.	Sept. 14.	Forfar	Dundee, Barry, Mr. J. Procter.	III.	Casella	9 a.m.	0 3	55	5·02 4·98 5·01 5·00 M 5·002	·1 ·2 ·3 ·4 ·5	500 1000 1490 1980 2480	−·001 −·002 correct. +·001 correct.	In garden rather sheltered, but probably not so much so as to vitiate the results.	228.
229.	Sept. 14.	Forfar	Dundee, Crombie, Dundee Water-works.	VIII.	....	....	0 3	522	11·22 11·32 11·28 11·31 M 11·283	·1 ·2 ·3 .4 1·0	....	+·001 +·002 +·002 +·003	In a railed enclosure, perfectly open in all directions.	229.
230.	Sept. 14.	Forfar	Dundee, Barry, Mr. J. Procter	VIII.	Mr. Procter	9 a.m.	0 3	55	11·72 11·67 11·68 11·77 M 11·710	·085 ·18 ·277	2525 5050 7576	−·008 −·006 −·002	Close to No. 228.	230.
231.	Sept. 14.	Forfar	Dundee, Craigton Reservoir, Dundee Water-works.	VIII.	....	....	0 3	481	11·20 11·45 11·50 11·32 M 11·367	·1 ·5 1·0	....	+·002 +·004 +·005	Very good position on open lawn. There is also a gauge, pattern No. V., but with a very flat rim.	231.
232.	Sept. 14.	Forfar	Dundee, Hill Head, Dundee Water-works.	VIII.	....	....	0 3	570	11·06 11·40 11·13 11·32 M 11·227	·1 ·5 1·0	....	correct. correct. +·002	Trees in N.E. 50 ft. distant and 30 ft. high. Pipe into receiver nearly 1·5 in. in diameter; will be reduced to ·1 in.	232.
233.	Sept. 14.	Forfar	Dundee, Hermon Hill, R. Adamson, Esq.	VIII.	....	monthly.	level	109	11·30 11·32 11·30 11·32 M 11·310	....	....	....	In garden, fully exposed; measuring-jar not accessible.	233.
234.	Sept. 14.	Forfar	Dundee, Westfield Cottage, E. Clark, Esq.	XII.	Lowden	9 a.m.	5 6	56	5·00 5·00 5·00 5·04 M 5·010	·01 ·1 ·2 ·3 ·4 ·5	50 500 1000 1490 1980 2480	correct. correct. −·001 +·001 +·002 +·002	On the top of the thermometer stand; rain drawn off by a tap. In a garden sloping to river.	234.
235.	Sept. 24.	Hampshire	Ryde, C. Scholefield, Esq., R.N.	XII.	Casella	....	3 0	40	5·03 5·01 5·02 5·00 M 5·015	·1 ·2 ·3 ·4 ·5	500 1000 1490 1980 2480	correct. correct. +·001 +·003 +·003	On a post in garden at E. end of Ryde.	235.
236.	Sept. 24.	Hampshire	Ryde, Esplanade, R. Taylor, Esq.	VIII.	Local	9 a.m.	6 0	20	12·1				In small yard at back of house and	236.

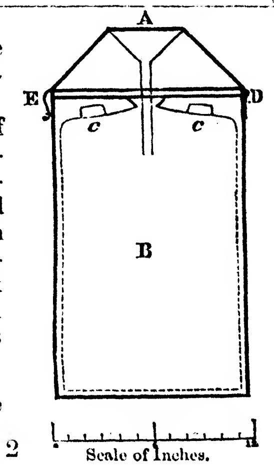
EXAMINATION OF RAIN-GAUGES (*continued*).

Reference number.	Date of examination.	County.	Name of station, owner, and observer.	Construction of gauge.	Maker's name.	Time of reading.	Height of gauge. Above ground.	Height of gauge. Above sea-level.	Diameters (that marked M = mean).	Equivalents of water. Scale-point.	Equivalents of water. Grains.	Error at scale-point specified in previous column.	Remarks on position, &c.	Reference number
	1867.						ft. in.	feet.	in.	in.				
									11·9				sheltered both by buildings and a tree due S. 16 ft. high and only 8 ft. distant.	
									12·0					
									12·0					
									M 12·000					
237.	Sept. 24.	Hampshire	Ryde, Esplanade, R. Taylor, Esq.	XII.	Casella	9 a.m.	6 0	20	5·00	·1	490	+·001	Close to No. 236.	237.
									4·98	·2	990	correct.		
									5·00	·3	1490	—·002		
									4·98	·4	2000	—·005		
									M 4·990	·5	2480	—·002		
238.	Sept. 27.	Hampshire	Osborne, J. R. Mann, Esq.	X.	Negretti & Zambra	monthly.	0 8	172	7·98	·1	1290	—·002	On grass plot; a hedge 5 ft. high was only 4 ft. distant in E.	238.
									7·97	·2	2500	+·002		
									7·97					
									7·96					
									M 7·970					
239.	Sept. 27.	Hampshire	Osborne, J. R. Mann, Esq.	IV.	Negretti & Zambra	9 a.m.	3 0	172	12·10	·065	2500	—·035	Close to No. 238.	239.
									11·90	·150	5000	—·038		
									12·00	·240	7500	—·034		
									12·01	·325	10000	—·038		
									M 12·003	·415	12500	—·034		
										·500	15000	—·025		
240.	Sept. 28.	Hampshire	Newport, Chapel St., Mr. E. G. Aldridge.	XI.	Negretti & Zambra	9 a.m.	8 8	53	5·01	·1	510	—·002	On apex of small outhouse, much sheltered by trees.	240.
									5·00	·2	1010	—·003		
									5·00	·3	1500	—·001		
									5·04	·4	1985	+·002		
									M 5·013	·5	2490	correct.		
241.	Sept. 30.	Hampshire	St. Lawrence, The Rectory, Rev. C. Malden.	XII.	Casella	9 a.m.	1 0	85	5·00	·1	500	—·001	Quite clear on lawn; ground sloping to S.	241.
									4·98	·2	1000	—·002		
									5·02	·3	1490	—·001		
									5·00	·4	1980	+·001		
									M 5·000	·5	2480	correct.		
242.	Oct. 1.	Hampshire	Ventnor, Belgrave House, Dr. Martin.	II.	Newman	9 a.m.	3 7	100	12·00	·05	1490	—·001	Clear except in N., where the house (three stories) is only 40 ft. distant.	242.
									12·00	·1	3000	—·005		
									12·02	·15	4260	+·001		
									12·02					
									M 12·010					

Note.—The preceding Tables are similar in every respect to those contained in the British Association Report for 1866; and in order that the present one may be complete in itself, part of the explanation there given is here repeated; as is also the Plate representing the various forms of gauge most generally used.

The present Tables contain the results of Mr. Symons's personal examination of gauges on the dates specified in the second column, and at the localities stated in the third and fourth columns. The pattern of the gauge is indicated by the Roman numerals which refer to the accompanying Plate; the next four columns are self-explanatory; then, as few gauges are true circles, four diameters (*i. e.* at intervals of 45°) are taken, and their mean is assumed as the mean diameter of the gauge and marked M; from this the area, and weight of an inch of water over that area, is readily obtained, and the difference between the computed value and that which the gauge showed when tested is the error of the gauge given in the last column but two; the last columns are self-explanatory.

A section is given of Gauge No. 172, it being of a type not represented on the Plate, yet of considerable importance, inasmuch as it is the pattern employed by Mr. Fletcher, F.R.S., on the Cumberland Mountains. The orifice is small, only 4 inches, in order to keep the volume of water within manageable limits; they are constructed with very thick double-lapped copper vessels dropped into stout iron cans provided with lock and hinges; the amount is measured with a glass like No. III.



c, *c* are handles, D is a hinge, and A E D falls down close on the body B.

Report on the best means of providing for a uniformity of Weights and Measures, with reference to the Interests of Science. By a Committee, consisting of Sir JOHN BOWRING, The Rt. Hon. C. B. ADDERLEY, *M.P.*, Sir W. ARMSTRONG, Mr. SAMUEL BROWN, Mr. W. EWART, *M.P.*, Mr. CAPEL H. BERGER, Dr. FARR, Mr. FRANK FELLOWS, Prof. FRANKLAND, Mr. GEORGE GLOVER, Prof. HENNESSY, Earl FORTESCUE, Mr. FREDERICK HENDRICKS, Mr. JAMES HEYWOOD, Sir ROBERT KANE, Prof. LEONE LEVI, Prof. W. A. MILLER, Prof. RANKINE, Mr. C. W. SIEMENS, Col. SYKES, *M.P.*, Prof. A. W. WILLIAMSON, Lord WROTTESLEY, Mr. JAMES YATES, *and* Prof. LEONE LEVI, *Secretary*.

SINCE our reappointment at Nottingham, your Committee have used their best endeavours to diffuse the knowledge of the Metric System, with a view to its extension throughout the world, and we have the pleasure to report that special and extensive opportunities have presented themselves for the purpose. The advantage of having the principal items in the statistics of the United Kingdom published in the terms of the Metric, as well as of the Imperial System, a practice which has been most advantageously introduced in some Government Departments, has been again brought by your Committee to the notice of the Board of Trade; but although this method has been repeatedly recommended by the International Statistical Congress, and also by the Committee of the House of Commons in 1862, the request has not been granted. Your Committee can scarcely admit that an arrangement, which would be found so convenient to this and to foreign countries, and which would so facilitate the general knowledge of the Metric System, should be refused on the ground of clerical difficulties, or because it may cause a trifling additional expenditure. The Committee hope that, on further consideration, the Board of Trade will see the advantage of complying with the wishes repeatedly expressed for such items of information.

The Mural Standard, which has been the subject of so much care and study, both as regards precision and material, has now been completed by Mr. Casella, Scientific Instrument Maker to the Admiralty, and is available for public use. It is made of white glazed porcelain, which is little affected by changes of temperature, and combines cheapness with elegance. The two units, the Yard and the Metre, with their divisions, authorized by law, are there shown in contact, so as to admit of easy comparison. The Yard, divided into feet, inches, and eighths of an inch, is painted in red; the Metre, divided into decimetres, centimetres, and millimetres, in blue. By very careful observation, it has been found that the measures on this instrument are exact to within the two hundred and fiftieth part of an inch, or the tenth part of a millimetre. It is fitted in a mahogany frame, for suspension on the walls of public buildings. Your Committee have ordered copies of the Mural Standard to be presented to the Board of Customs of London and Liverpool, the University of Oxford, and the office of the Warden of the Standards. By the kindness of Mr. Yates, a copy of the Mural Standard has also been presented to the Conservatoire des Arts et Métiers in Paris. It is much to be desired that the Mural Standard be extensively made known, and your Committee would recommend the same to the special attention of the Chambers of Commerce and municipal authorities.

In February last, your Committee, in conjunction with the Council of the British Branch of the International Decimal Association, invited a con-

ference with deputies from the Chambers of Commerce in the United Kingdom, and the Consular authorities in London. The conference was held at the Society of Arts, under the presidency of Sir John Bowring, and the foling resolutions were unanimously passed:—

That the permissive use of Metric Weights and Measures in the United Kingdom, without corresponding powers for legalizing authorized standards of the same, and the stamping of Metric Weights and Measures in use, is calculated to cause much inconvenience in trade, and to frustrate the practical adoption of the system; and that it is therefore desirable that the Department of the Board of Trade charged with the custody of Imperial Weights and Measures, be also authorized to provide and maintain the standards of Metric Weights and Measures, and to stamp and verify those in general use.

That in order to facilitate the use of the Metric System, it is desirable that the same be introduced into the public departments, especially in the Post-office and the Customs, by the official preparation of the Tariff in Metric equivalents, with authority to levy duty according to the same; and the publication of the principal results of the statistics of the Board of Trade in Metric and Imperial values.

That this Conference recommend the Chambers of Commerce of the United Kingdom to use means for promoting the voluntary use of the Metric System among merchants, manufacturers, and tradesmen, such as the preparation of special tables, available in the various trades, for converting prices and quantities from the Metric into the Imperial System, and *vice versâ*; and the exhibition of Mural Standards of the Metre in public places in the principal ports and market-towns.

That in the opinion of this Meeting, the International Monetary Convention lately entered into by France, Italy, Belgium, and Switzerland, for the purpose of giving a common weight, fineness, and currency to their standard Coins, is deserving approbation as a measure calculated to facilitate and extend the commercial, banking, and exchange operations between those nations themselves, and foreign countries having dealings with them.

And this Meeting is further of opinion that the conditions of the International Monetary Convention, so far as they may be found applicable to the Metallic Currency System of the United Kingdom, are well worthy of the attentive consideration and support of all who are interested in the progress of and intercommunication between nations.

That it is desirable that the Chambers of Commerce should be represented at the Conference to be held in Paris in connexion with the special Exhibition of Weights, Measures, and Coins, at the approaching Universal Exhibition.

The most important event, however, which is likely to exercise considerable influence in the future discussion of the question, is the Conference held in Paris at the suggestion of your Committee and of the Council of the International Decimal Association. The Conference having been held at a time when Parliament was sitting and the Courts of Law were open, no large representation could attend from this country, yet Mr. Samuel Brown and Professor Leone Levi attended on behalf of your Committee and they had the advantage of having with them Mr. Louis P. Casella, the constructor of the Mural Standard, Mr. Muspratt and Mr. Blood, representing the Liverpool Chamber of Commerce, and Mr. Joseph Wrigley, representing the Huddersfield Chamber of Commerce. The Conference was attended by representatives from many countries, including Austria, Spain, Portugal, Denmark,

Sweden, Norway, Prussia, Wurtemberg, Bavaria, Russia, Italy, Morocco, Tunis, Brazil, South America, and the United States; and was presided over by M. Mathieu, of the Institute. The first question discussed was that of Weights and Measures, and a report was read on the subject, which was prepared by M. Jacobi, of the Imperial Academy of Sciences of St. Petersburg, and adopted by the organizing Committee. Starting from certain fundamental propositions in favour of the Decimal system of calculation and of the Metric system especially, the report showed how far that system had been extended in different countries, specifying those which have already adopted it entirely and in an obligatory manner, such as France, Belgium, the Netherlands, Italy, the Roman States, Spain, Portugal, Greece, Mexico, Chili, Brazil, New Grenada, and other Republics of South America; those which have more or less borrowed from it, such as Switzerland, Baden, Prussia, Bavaria, Wurtemberg, Austria, Denmark; those which have introduced the Metric system in a permanent manner, as the United Kingdom, and the United States; and those which have nothing in common with the Metric system. After this survey, the report entered into a detailed account of the advantages which would result from the use of the system in different branches of labour, in the teaching of arithmetic in primary schools, in scientific researches and memoirs, in commercial transactions, in industry and machinery, in postal tariffs, telegraphs, and customs duties. As regards the use of its nomenclature, the report is not in favour of any material alteration, and far less of using old names for new quantities; nor does it favour the combination of the old and new systems, such as the use of the foot side by side with the metre even in a period of transition. In conclusion, the report recommended the immediate teaching of the Metric System in schools, and the use of the same in statistical and other public documents. After some discussion the report was put to the vote, and was carried unanimously.

Doubts having been expressed as to the exact correspondence between the standards kept at the Archives and those at the Conservatoire des Arts et Métiers, and some uncertainty existing respecting the method to be pursued for obtaining an exact standard in other countries, the prototype being in Paris, Général Morin and M. Tresca, Conservator and Subconservator of the Conservatoire des Arts et Métiers, stated that on the 5th October, 1863, his Excellency the Minister of Agriculture, Commerce, and Public Works, had appointed a Commission, composed of themselves, with M. Silberman, Conservator of the collections, and M. Froment, Constructor of instruments, charged to make an official comparison between the prototype standards kept at the Archives, with those deposited at the Imperial Conservatoire des Arts et Métiers, more particularly destined to be used for comparisons with the standards made by or for the different governments which might adopt the Metric System. The prototype standard Metre at the Archives is of platinum, has no inscription or mark whatever, and is a Mètre à bout. It is in a case, having a tablet with the following indication:—

METRE

Conforme à la loi du 18 Germinal an. III.

Présenté le 4 Messidor an. VII.

And outside the inscription the words:

Fait par Lenoir.

That at the Conservatoire has precisely the same inscription, is in every way identical with the other, and seems in a better state of preservation. The

Kilogram of the Archives is a cylinder of platinum, without any mark or inscription, in a box having the following inscription:—

KILOGRAMME
Conforme à la loi du 18 Germinal an. III.
Présenté le 4 Messidor an VII.
Fortin f.

The Kilogram at the Conservatoire has been recently re-constructed (1864), and has the same form with the other.

Two distinct comparisons were made between these Metres and Kilograms, and the result was that those at the Conservatoire were found to be 1·00000329 and 1·00000072 respectively, as compared with those of the Archives. In answer to the assertion that a cubic centimètre of distilled water at 4° Centigrade of temperature did not in fact furnish the exact basis for the weight of the Kilogram, it was stated that the difference was quite infinitesimal, and that it had no value whatever when the exact standard was kept, and that corresponded with the standard Kilogram of all nations. The statements of Général Morin and M. Tresca were considered highly satisfactory, as giving every guarantee of sufficient exactitude, and completely dispelled every doubt suggested on the subject. A Commission appointed by the Committee afterwards inspected the Metre and Kilogram at the Archives and Conservatoire, and having found them as described, made a protocol signifying their satisfaction at the care with which the standards were preserved, and at the results of the verification made.

With reference to the uniformity of weights and measures, your Committee have therefore much pleasure in reporting that their task has been greatly accelerated by the Conference described, and that there is every prospect that the principal nations will speedily adopt the Metric System. In the United Kingdom much remains to be done on the subject. As yet the Metric System, though rendered legal, has made but little progress either in general practice or even in the education of the people, and your Committee are of opinion that the most efficient mode for promoting the early introduction of this salutary reform is to make the use of the Metric System compulsory at no distant period. They recommend, therefore, amongst other measures, that a bill be speedily introduced in Parliament providing that after a given time the use of metric weights and measures shall become compulsory throughout the United Kingdom.

As regards the coinage, your Committee have to report the proceedings of two important Conferences. The Monetary Convention signed at Paris on the 23rd December 1865, by the representatives of France, Belgium, Switzerland, and Italy, having established an agreement between four important countries whereby the coinage of each of them was made legally current in all the others, great efforts have been made to induce other nations to give their adhesion to the Convention. Hitherto the Convention was made between nations which had already an identical system of coinage. The object of the Conference was to consider by what means those nations which had a totally different system could be also united. This Conference, called by the French Government, was held at the Ministry of Foreign Affairs, under the presidency of His Imperial Highness the Prince Napoleon, and was attended by representatives from Austria, Baden, Bavaria, Belgium, Denmark, the United States, from Great Britain, Greece, Italy, the Netherlands, Portugal, Prussia, Russia, Sweden, Norway, Switzerland, Turkey, and Wurtemberg. The results of their deliberations were as follows.

It was unanimously agreed:—

That the monetary unification may more easily be realized by the mutual coordination of the existing systems, taking into account the scientific advantages of certain types, and the number of persons who have already adopted them, than by the creation of a new system altogether independent of the existing ones.

That for that purpose, the system agreed on by the Monetary Convention of 1865 should be taken principally into consideration, subject to any improvements of which it may be capable.

It was agreed by all, except the representatives of the Netherlands,—

That it is not possible to attain such identity, or even a partial coincidence, in such monetary types in an extended area, on the basis and on condition of the exclusive adoption of a silver standard; but that it is possible to attain it on the basis of a gold standard, allowing each State to preserve the silver standard in a transitory manner.

It was agreed by all, except the representatives of Russia and the United States,—

That the advantage of internationality, which the coinage of the metal taken for common standard would possess, is not a sufficient guarantee for its being maintained in circulation in all the States, but that it is necessary to stipulate that in the countries which continue to use the silver standard only, and in those which have a double standard, the relation between the value of gold and silver should not be established on too low a footing, in order to give due facility for the practical introduction of the gold coinage.

It was unanimously agreed,—

That for the success of the Monetary unification, it is necessary to fix types having a common denominator for the weight of the gold coin, with an identical fineness of 9/10 fine.

The proposal that the common denominator should be the piece of five francs was adopted by a majority of 13 votes against 2, the representatives England and Sweden having voted against, and those of Prussia, Bavaria, Baden, Wurtemberg, and Belgium having abstained from voting.

It was then unanimously agreed,—

That the gold coin of the common denominator of 5 francs should have legal course in all the States which are mutually bound by the Monetary Convention.

It was agreed by all, except the representatives of Prussia, Baden, and Wurtemberg, who abstained from voting,—

That it would be useful that the types of coinage determined by the Monetary Convention of 23rd December 1865, should be in the interest of unification, and consequently of reciprocity, completed by new types, for example, of 25 francs.

But for the proposal that a piece of 15 francs be also added, the representatives of seven countries voted in favour, those of seven voted against, and those of six, including Great Britain, abstained from voting.

It was unanimously agreed—

That the Conference expresses the hope that the measures which may be adopted by the Governments of the different States in order to modify their respective monetary systems in accordance with the bases indicated by the Conference, should be made as much as possible the subjects of diplomatic conventions.

And it was unanimously agreed—

That soon after the reception of the answers which may be given by the different States to the official communication, which will be made to them of the labours of the Conference by the French Government, that Government may, if necessary, call a new Conference.

But on the question as to the time when such answers should be given, the representatives of ten countries voted for before the 15th February prox., those of five voted in favour for the 1st October 1867, those of the United States for the 15th May 1868, and those of Great Britain for the 1st June 1868. Those of France and Spain abstained.

Such were the resolutions of the International Monetary Conference, which had an official character, and whose proceedings were to a certain extent binding on the States represented. The other Conference, whose decisions on weights and measures we have already reported, was also presided over by Prince Napoleon, who took the chair on the day when the monetary question was discussed.

The Committee had not prepared a report on this subject, as in the case of weights and measures, but had adopted the following resolutions, which were submitted to the Conference, and adopted with only some verbal alterations.

Whereas the adoption of a uniform system of coinage would present evident advantages as regards convenience and economy in the settlement of international exchange, and recommends itself to the attention of all enlightened governments;

Whereas, on the other hand, such a desideratum cannot be realized unless several nations are prepared to sacrifice their old and habitual instruments of traffic, whilst it is important that the change may be effected in a gradual and continuous manner, and that the mode of effecting this change should be as simple as possible and free from all incidental complication;

The Committee proposes as follows:—

1. It is necessary in the first instance that the different governments interested in this question should agree as to the same unit in the issue of their gold coins.

2. It is desirable that this coin be everywhere coined of the same fineness, of nine-tenths fine.

3. It is desirable that each government should introduce, among its gold coins, one piece at least of a value equal to that of one of the pieces in use among the other governments interested, so that there may be among all the systems a point of common contact, from which each nation may afterwards advance in gradually assimilating its system of coinage to that which may be chosen as a uniform basis.

4. The series of gold coins now in use in France, being adopted by a great part of the population of Europe, is recommended as a basis of the uniform system.

5. Whereas, in consequence of accidental and happy circumstances, the most important monetary units may be adapted to the piece of five francs in gold by means of very small changes, this piece seems the most convenient to serve as a basis of a monetary system; and the coins issued upon such a basis may become, as soon as the convenience of the nations interested permit, multiples of this unit.

6. It is desirable that the different governments should decide that the coins issued by each nation in conformity with the uniform system proposed and agreed, should have legal currency in all other countries.

7. It is desirable that the system of double standards be abandoned

wherever it yet exists, that the system of decimal numeration be universally adopted, and that the money of all nations be of the same fineness and the same form.

8. It is desirable that the governments should come to an understanding for adopting common measures of control, so as to guarantee the integrity of the coinage both when issued and whilst in circulation.

Your Committee will take these and other plans for the decimalization of the coinage into their serious consideration, and as soon as possible will endeavour to propound one which they hope may meet all the requirements of the question.

In conclusion, your Committee are happy in reporting that in their action they have obtained the valuable cooperation of the Council of the International Decimal Association, and they trust that in the difficult and extensive task they have before them they will obtain the active sympathy, and assistance of the members of the British Association.

The labours of the Conference will, we trust, place the great and difficult question of the decimalization of the coinage in the United Kingdom on a satisfactory basis; and it is time that it should be taken up in a practical and business-like manner.

Your Committee are perfectly agreed on the two great conditions that the coinage should be international and decimal; but they have not yet come to a satisfactory conclusion as to the unit which would best satisfy these desiderata. The proposition of the Conferences to take the five-franc piece in gold as a basis deserves consideration, though as a unit it would be impracticable, being too small as a gold coin, very easily lost, too costly to produce, much subject to wear and tear, and not sufficiently large for transactions of finance and commerce. The five francs could only be used as a submultiple, and upon this two plans have been presented. One is to take the 10-franc piece equivalent nearly to 100 pence; another is to alter the sovereign to the exact equivalent of 25 francs. The Committee will carefully consider these and other plans, with a view to the realization of an object so desirable as an international coinage, and will report on the subject in due time.

Report of the Committee on Standards of Electrical Resistance.

The Committee consists of Professor Williamson, Professor Sir C. Wheatstone, Professor Sir W. Thomson, Professor Miller, Dr. A. Matthiessen, Mr. Fleeming Jenkin, Sir Charles Bright, Professor Maxwell, Mr. C. W. Siemens, Mr. Balfour Stewart, Mr. C. F. Varley, Professor G. C. Foster, Mr. Latimer Clark, Mr. D. Forbes, Mr. Charles Hockin, and Dr. Joule.

The Committee have much pleasure in reporting that during the past year considerable progress has been made, and that the principal instruments required by the Committee for experiments have been completed and are in use.

The most important experiments have been those conducted by Dr. Joule, having for their object the determination of the mechanical equivalent of heat, by observing the heat generated in part of a voltaic circuit, the resistance of which was measured in absolute units by means of the standard of resistance issued by the Committee.

Last year preliminary experiments of this kind had been made by Dr. Joule, and the agreement which he then reported between his mechanical equivalent obtained by frictional experiments and that obtained by the electrical method was so close as to lead to a suspicion that it was partly fortuitous.

The experiments, which have this year been conducted with every possible care, give 783 as the value derived from the B.A. standard of resistance, while 772 is the well-known number derived from friction.

The details of the experiments are contained in an Appendix which accompanies this Report. Dr. Joule states his opinion that the electrical method has been carried out with greater accuracy than the frictional method, assuming the B.A. standard to be an exact decimal multiple of the absolute unit. The following extract from Dr. Joule's Report will show the laborious nature of the experiments. He says, "The last and most perfect series of experiments comprise thirty for the thermal effect of currents in the spiral, thirty for the effect of radiation &c., and thirty for the horizontal intensity of the earth's magnetism." Dr. Joule expresses himself willing to make a new determination by friction. Meanwhile the experiments already completed remove all fear of any serious error, either in the number hitherto used as "Joule's equivalent," or in the B.A. standard, a fear which hitherto, remembering the very discrepant results obtained by others, has been very naturally entertained even by the Sub-committee, from whose experiments the standard was constructed.

In connexion with the measurement of resistances, Mr. C. W. Siemens has invented a simple and excellent contrivance, by which the measurement of resistances can be made by persons wholly unaccustomed to electrical experiments. They have only, after the necessary connexions are made, to turn a screw till a needle stands opposite a fiducial mark, when the resistance required may be read directly on a scale with considerable accuracy. Mr. Siemens proposes to apply this invention to pyrometers, where the resistance read will indicate the temperature, and the only electrical connexions required will be joining of the battery wires to two terminals. Other applications of this invention will doubtless arise, and extend the practical application of electrical measurements. A full description of the instrument is contained in the Appendix. Mr. Siemens reports very favourably of this instrument, which possesses considerable advantage in cheapness and portability. Mr. Siemens has constructed the instrument, and made the experiments entirely at his own expense.

An instrument similar in object, and suggested by the above, is also described by Mr. Jenkin in an Appendix.

Mr. Hockin has tested the constancy of the standard resistance-units, with satisfactory results, except in the case of one mercury tube. The exact results of Mr. Hockin's comparisons are appended. He suggests that lead-glass was used for the mercury tube, and that the glass may consequently have been injured by the nitric acid used to clean it.

Mr. Hockin has also made interesting experiments on the construction of large resistances by the use of selenium. He finds that resistances of one million units and upwards can be made of this material, and that these artificial resistances maintain a sensibly constant resistance at high temperatures, such as 100° C. It is hoped that these very high artificial resistances will be found useful in practice and much superior to those hitherto constructed of gutta percha, or other insulators, which were of comparatively little use in accurate work, owing to absorption, change of resistance with

temperature and inconstancy when kept for any considerable time. These valuable experiments have not caused any expense to the Association.

The determination of a unit of capacity has occupied Dr. Matthiessen, Mr. Hockin, Mr. Foster, and Mr. Jenkin during the last two years.

Very considerable difficulties have been encountered, and are not yet wholly overcome. The methods by which both the electrostatic and electromagnetic units can be determined, and multiples or submultiples prepared, are sufficiently simple in theory, but they assume that the condensers or Leyden jars compared have really a definite capacity, and that with a given electromotive force, between the induction surfaces, a definite quantity of electricity will be contained in the jar or condenser. This is very far from true with condensers of ordinary form. Whether the dielectric separating the plates be glass, mica, gutta percha, paraffin, ebonite, or any other known solid insulator, an absorption of electricity takes place; the longer the plates are charged, the more electricity the condenser will contain, and conversely, it will continue to discharge itself for a very long period after the inner and outer armatures have been joined. With some of the best insulators the effect will continue for hours, if not for days. Condensers made with these solid dielectrics have therefore no definite measurable capacity. This capacity will differ according to the time during which they have been charged, and it may also vary with extreme variation in the electromotive forces employed, although this latter change has not been detected when the differences of potential are such as between one Daniell's cell and two hundred.

Only gaseous dielectrics appear free from this embarrassing peculiarity, called absorption, polarization, or residual charge. One object of the Subcommittee has therefore been to construct condensers in which air alone separated the induction-plates. But new difficulties arose in carrying this idea into practice. Some support for each plate was necessary, and then leakage occurred from one plate to another over the surface of any small insulating supports employed, such as glass balls or vulcanite stems. It was possible, by great care in drying the air, occasionally to make condensers of this type, which would remain insulated for a short time, or even for some months; but long experience has shown that an artificially dried atmosphere cannot be conveniently maintained in any instrument which is not hermetically sealed.

Dust also accumulated between the plates of the trial-condensers; this altered their capacity and increased the leakage from plate to plate. Even a single filament of dust, by springing up and down between the two electrified surfaces, would occasionally bring them to the same potential with great rapidity, neutralizing the charge; moreover a condenser of this type could not be taken to pieces and cleaned, for no mechanical contrivances could ensure that the parts after cleaning would return to their original position so exactly as to constitute a condenser of the same capacity, before and after the cleaning. It is therefore clear that an air-condenser can only be constructed in a hermetically sealed case, containing an artificially dried atmosphere; and even with these conditions, excluding the graduated and adjustible condensers, which were first tried, the air-condenser is not easily constructed. For large capacities, which are alone useful in connexion with practical telegraphy, the plates require to be so numerous and large as to make the expense great and the bulk very inconvenient.

It is hoped by the use of tin plates, soldered to metal rods, and supported on insulated stems inside a soldered metal case, that these objections may be partly avoided; but meanwhile practical men have introduced condensers of

a more convenient form, overlooking the disadvantage which they all possess of ill-defined capacity.

These condensers consist of sheets of tinfoil separated by paraffin and paper, a preparation of gutta percha, or mica—three plans adopted by Mr. Varley, Mr. Willoughby Smith, and Mr. Latimer Clark respectively.

Condensers of this type have been made approximately equal to a knot of some submarine cable, and the rough units thus introduced are gradually creeping into use, although all electricians have been anxious that the Committee should issue a more scientific standard. Under these circumstances, Mr. Jenkin has adjusted a mica-condenser, approximately equal to 10^{-14} absolute electromagnetic units. The capacity of this condenser is assumed as that which it possesses after electrification for one minute, and is measured by the discharge through a galvanometer, in the manner usually practised when testing the charge of a submarine cable. The formula for obtaining the measurement in absolute units from the throw of the needle is very simple, requiring only observations of the time of oscillation, of a resistance in absolute measure, and of a deflection of the galvanometer-needle. All of these observations can readily be made, so that their accumulated error cannot exceed one per cent.; and for the present purpose this accuracy is sufficient, inasmuch as, when using the condenser, small variations inevitably occur, arising from the residual discharge. While therefore the new provisional unit of capacity has no claim to a high scientific accuracy, it will supply a practical want and introduce a unit based on the principles adopted by the Committee, in place of the random measures supplied by a knot of Persian Gulf or Atlantic cable.

No decision has yet been arrived at whether the new unit shall be issued by the Committee, or on Mr. Jenkin's own responsibility, nor has the price been fixed.

The experiments by which it has been obtained are given in an Appendix.

The practical applications of the standard of capacity are important. It will allow the capacity of submarine cables to be universally expressed in comparable figures, and may lead to improvement by the diminution of the specific inductive capacity of the insulator, precisely as the introduction of units of resistance has assisted the improvement in insulation and conductivity.

The electromagnetic capacity standard will also, by comparison with the electrostatic standard about to be made, furnish one mode of determining the constant called v in previous Reports, a number of much importance in the theory of electricity.

The next unit or standard for consideration is that of the difference of potentials or electromotive force in absolute measure, concerning which the experiments have been wholly in Sir William Thomson's hands. He reports that he has at last succeeded in constructing a series of electrometers capable of measuring differences of potential ranging from $\frac{1}{400}$ of a Daniell's cell up to 100,000 cells, and that these measurements can all be reduced to absolute units by comparison with one instrument of the series.

This class of instruments has been created by Sir William Thomson, who year by year has produced electrometers each surpassing its predecessor, both in accuracy and delicacy; but although those who have had practical experience of the admirable results obtained by these, have for the last two or three years believed that the limit of excellence has been reached, Sir William Thomson has not ceased to invent better and simpler forms, until

the instruments now supplied surpass every expectation of practical electricians and furnish, indeed, a new engine for electrical research.

The chief difficulties encountered have been the insulation of the Leyden jar, which has formed an essential part of all the contrivances, its maintenance at a constant potential, and the reduction to absolute measurement; in the present instrument absolutely perfect insulation is no longer required; for by a new device for converting mechanical force into statical electricity (first constructed by Mr. Varley in 1859) Sir William Thomson is able at any moment to replenish the jar by a few turns of a handle, and by a gauge electrometer, he can insure that the same charge is constantly maintained in the instrument. The difficulty of the reduction to absolute units consists in the difficulty of comparing the extremely small forces produced by electrostatic attraction, with the force of gravitation, and in the accurate measurement of the extremely small distances which separate the attracting surfaces. Sir William Thomson reports that these difficulties have been overcome in his opinion, and that he will be shortly in a position to construct and issue a simple pattern of an absolute electrometer or gauge of potential which will serve as a standard for general use.

Further experiments and tests are, however, required before this can be done, as any precipitation would only injure the interests of the Committee. It is right here to mention that the above experiments have been carried out almost entirely at the expense of Sir William Thomson.

The replenisher, which is founded on the principle of the electrophorus, may very possibly supersede the old form of electrical machine entirely; it has some analogy with the electromagnetic machines lately invented by Mr. C. W. Siemens and Professor Wheatstone, by which intense dynamic effects are evolved from the smallest initial trace of magnetism, by the conversion of mechanical force into electric currents, and was, indeed, suggested by this invention to Sir William Thomson, who reinvented the plan patented by Mr. Varley*.

A modification of the same contrivance will allow the comparison of extremely minute quantities of electricity, such, indeed, as might be accumulated on a pin's head; by a series of rapid inductions a charge is accumulated on the electrode of an electrometer, which may be made equal in potential to that on the pin's head, but infinitely exceeding it in quantity; the effect of this charge in the electrometer can then be observed without difficulty, and any increase or diminution in the quantity of electricity on the pin's head or proof plane can be detected, and the rate of loss or increase observed. The potentials to which various small bodies are charged can also be observed by the same method, the advantage of which consists in the fact that the original charge on the body tested is undisturbed by the test, whereas by any of the older tests the charge was altered by being touched by a proof plane or by the electrode of the electrometer.

A similar plan has already been proposed by Mr. Varley and Sir William Thomson, with a water-dropping arrangement, but the mechanical contrivance is in all ways preferable. No expense has been incurred by the Committee for these instruments or experiments.

Passing to the unit of current, the Committee regret that no experiments have yet been made with the large absolute electrodynamometer constructed with the funds granted by the Royal Society. Much difficulty has been experienced in finding a sufficiently solid foundation in London, and probably the instruments must be moved into the country for accurate use.

* A similar plan was proposed by Mr. Nicholson in 1785: *vide* Phil. Trans.

A portable electrodynamometer has been constructed which will be suitable for distribution as a standard instrument. It can be compared with the large absolute instrument, and can also be compared directly with the most sensitive astatic galvanometers yet made, as has been already proved by experiment. These instruments cannot be distributed until further experiments on their constancy have been made.

Sir William Thomson, at his own expense, has also constructed an electrodynamometer for absolute measure. His results will check those obtained in London, and the portable standard will also be tested by being sent backwards and forwards between Glasgow and London, to be compared alternately with the absolute instruments.

The determination of "*v*," the ratio between the electrostatic and electromagnetic units, is also an object pursued by the Committee. Sir William Thomson has made preliminary experiments, and has obtained numbers for this constant by the aid of the absolute electrodynamometer, and the absolute electrometer already named. The number he has obtained differs so considerably from that hitherto received that he prefers to extend his experiments before publication. The same remark applies to the measurement of the electromotive force of a Daniell's cell, made by the absolute electrometer.

It is hoped that the present Report contains satisfactory evidence that valuable work is being done by the Committee, and that the sums of money liberally granted by the Association have been expended on proper objects.

It will be seen that these grants have stimulated further expenditure on the part of more than one member; and thanks are also due to the Electric and International Telegraph Company, for the liberality with which they have lent large batteries, thereby saving much expense. The Committee are willing to be reappointed, and require no grant of money for the ensuing year.

APPENDIX.

I. *On a "Resistance-Measurer." By* C. W. Siemens, *F.R.S.*

For the measurement of small resistances the method formerly employed was that of the tangent galvanometer, which method is still valuable in the determination of resistances which are inseparable from a difference of electric potential, such, for instance, as a galvanic element.

In measuring wire-resistance, more accurate and convenient methods have been devised, amongst which that of the common differential galvanometer and that known as Wheatstone's balance hold the most prominent places.

But both these systems have disadvantages which render them insufficient in a great many cases. For instance, in the first method a well-adjusted variable-resistance-coil is necessary, which, if the method is intended to be applicable between wide limits, will have impracticable large dimensions. The bridge method, though very beautiful, requires three adjusted coils, and frequently gives rise to calculations, which renders it unavailable for unskilled operators. The sine method, which is the most suitable for measuring great resistances, requires even a superior amount of skill and mathematical knowledge on the part of the operator.

Many years' experience of these methods made me feel the want of an instrument which would, by its simplicity of construction and ease of manipulation, be capable of employment by an unskilled operator with a degree of exactness equal to that of the bridge method.

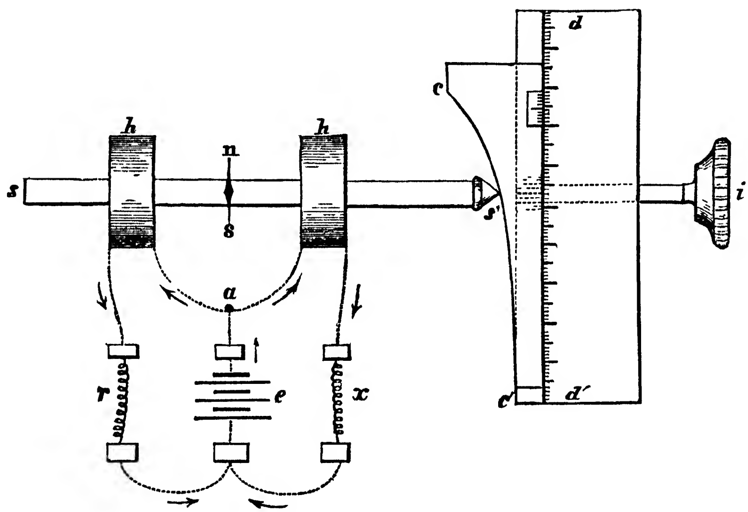
The condition upon which such an instrument could be successful appeared to be the following:—

1. The employment of a zero method, by which the galvanometer-needle should always be brought to the direction of the magnetic meridian, or the same given point upon the scale, and therefore be independent of the unknown function of the angle of deflection.

2. The readings to be made upon a simple lineal measure divided into equal parts signifying equal units of resistance.

3. The employment of a single and unalterable comparison-resistance.

The apparatus constructed to fulfil these conditions is represented by the following diagram:—



Two equal and parallel helices, *h* and *h'*, are fixed upon the common slide *s s'*, which moves in the direction of its length between guide rollers. This motion is effected by the end *s'* armed by a facing of agate, which presses against the face of the metal curve *c c'*. The latter is fixed upon a slide moving in a groove in the rule *d d'*, at right angles in the direction *d d'* by means of a milled head *i*, on the axis of which is a pinion gearing into a rack underneath the straight edge of the curve *c c'*. The rule *d d'* is graduated in equal parts; and opposite to the divisions is a nonius up the straight edge and the curve, to divide each degree into ten parts. Whenever the milled head *i'*, therefore, is turned, the position of the curve is altered; and as the point *s'* of the bobbin-slide is pressed against it by means of a spring, the bobbin follows it in all its movements.

The wires of the two bobbins are connected together, in the common point *a*, with the pole of a galvanic battery *e*, the other pole being connected with two resistances R, and through these with the remaining end of the galvanometer-helices. The resistance R is made constant, and adjusted so that when $x=0$ the index of the curve stands exactly opposite the zero of the graduated scale *d d'*, the unknown resistance being represented by x.

It is evident that, the resistance in the bobbins being equal, as also their dimensions and initial magnetic effects upon the needle suspended between them, if we make the resistance x equal to R, the current in the two branches

will be equal, and the magnet-needle therefore balanced between them only when the helices are equally distant from it. Should, however, either of these resistances preponderate, the strength of current in that branch will be lessened; and in order to reestablish the balance it will be necessary to shift the bobbins, approaching the one in which the weaker current is circulating towards the suspended magnet.

The instrument is erected upon a horizontal metal table standing upon three levelling-screws. The bobbin, the suspended magnet, and dial plate for observing the zero of the pointer are contained in a glass case, supported by four brass pillars. The instrument is supplied with terminals for the battery-connexions, and a current-breaker for interrupting the battery-circuit. Opposite to these are four terminal screws for receiving the ends of the resistances R and x, with contact-plugs between them, in order to quickly establish a short circuit in case the operator should be in doubt towards which side he has to move the adjusting-curve. Two constant resistances accompany the apparatus R—that which is used during the measurement, and a, a resistance of known value, which is introduced between the terminals x in order to enable the operator for his own security to make a control measurement by which he may verify the accuracy of the instrument at any time. Another purpose of this resistance is to facilitate the readjustment of the zero-point, in case the galvanometer should at any time be cleaned or a new silk-fibre put in.

In constructing the sliding curve of this instrument, it might be determined by calculation from the formula given by Weber for the deflection produced by a circular current of known magnitude upon a magnetic point, and from the given distance of the coils from each other. I prefer, however, in practice to determine the curve of each separate apparatus empirically, because it is not possible to coil a helix mathematically true, or to set it, when coiled absolutely at right angles to the plane of its horizontal motion.

In the determination of each curve I use a delicately adjusted rheostat or scale of resistances in the circuit of x, giving it varying values corresponding to the equal divisions of the engraved scale, and constructing the curve according to the position which it is found necessary to give to the point s' in order to arrive at the magnetic balance. With each instrument it would be possible to have two values of R—one expressed in mercury and the other in B.A. units; and in order to measure at pleasure in either of these units, it would only be necessary to insert the one or other between the terminal screws for R.

The instrument has been found to be very convenient for the measurement of the wire-resistances of overland lines, or for the reading of resistance thermometers; it reduces the operation and the observation of the zero position of a needle, and the reading upon a graduated scale, which can be performed by a person of ordinary intelligence without experience in electrical measurement. In accuracy and range it equals the bridge method, while as regards portability and cheapness of apparatus the advantages are decidedly in its favour*.

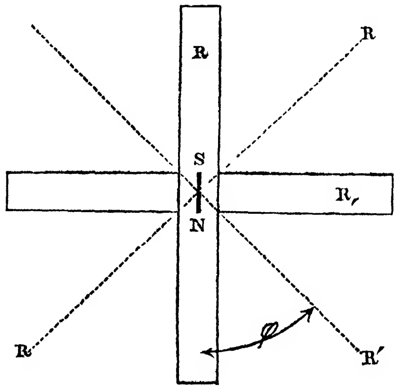
II. *On a Modification of Siemens's Resistance-Measurer.* *By* Fleeming Jenkin, *F.R.S.*

The following method of measuring resistances was suggested to Mr. Jenkin by the above invention of Mr. Siemens:—

Let two tangent galvanometer-coils of equal magnetic moment be fixed

* I have lately constructed the same instrument on this principle with a circular instead of a straight sliding-piece, which gives the advantage of a longer graduated scale in the form of a circle. The circular sliding curve is adjusted by radial set screws in a solid ring working in a V-groove round the galvanometer.

together at right angles, with a short magnet hung in their centre, having a long light index pointing at a fiducial mark when the needle is in the magnetic meridian. Let the battery and coils be so joined that the current shall divide in the ratio of the resistances in the two coils, and shall pass in such a direction as to tend to turn the needle in opposite directions.



The dotted lines show the position of coils when the current is passing.

Let one coil with a resistance R at the beginning of the experiment stand in the magnetic meridian, and the other coil with a resistance R_1 in a plane perpendicular to the meridian; and when the current is passing in such a direction that R tends to turn N S in the direction of the arrow, let the coils be turned till the needle is again brought to the fiducial point and the coil R_1 makes an angle ϕ with the magnetic meridian, then we have $R = \tan \phi\, R_1$; for the force exerted by the coil R_1 to deflect the needle in the direction of the arrow will then equal $m \sin \phi$; the force exerted by the coil R_1 to deflect the needle in the opposite direction will be $m_1 \cos \phi$; and we have $m \sin \phi = m_1 \cos \phi$, or $\frac{m_1}{m} = \tan \phi$, where m and m_1 are the couples experienced by the magnet under the action of the two coils, but as we have supposed these coils to have equal magnetic moments with equal currents, $\frac{m_1}{m} = \frac{R}{R_1}$; therefore $R = \tan \phi\, R_1$. R and R_1 need not be the resistances of the galvanometer-coils only, but may consist of two parts, $G + r$ and $G_1 + r_1$, where G and G_1 are the resistances of the galvanometer-coils, but r and r_1 are added resistances. Thus, when G G_1 and r are known, r_1 can be obtained by a simple observation.

If $G + r$ be one, one hundred, or one thousand units, the resistance of r_1 will be equal to the tangent of ϕ, or to one hundred or one thousand times that tangent respectively minus in each case a constant $= G_1$.

If the range of the instrument were not required to be very great, the coils would be turned by the pushing of a straight slide, equal divisions on which would correspond to equal increments of the tangent of ϕ, and the scale would be numbered, so that the resistance r_1 should be read off directly, as in Mr. Siemens's instrument.

The tangent coils should be made of German-silver wire, and might be arranged as practised by Helmholtz and Gaugain. Theoretically, the range of each instrument would be infinite, *i. e.* any instrument would be capable

of measuring an infinitely small or infinitely large resistance; but clearly the resistance of $G + r$ should be so arranged in each case that the angle observed was not very different from 45°. The range of the instrument may be further increased by the use of elements.

III. *Comparison of B.A. Units to be deposited at Kew Observatory.* *By* C. Hockin.

The following Table shows the value of the different copies of the B.A. units that have been made for preservation at Kew:—

Material of coil.	No of coil	Date of observation.	Temperatures at which coil has a resistance $=10^7 \frac{m}{s}$	Observer
Platinum-iridium alloy..	2	January 4, 1865	15°·5 C.	C. H.
		June 6, 1865	16·0	A. M.
		February 10, 1867	16·0	C. H.
Platinum-iridium alloy..	3	January 4, 1865	15·3	C. H.
		June 6, 1865	15·8	A. M.
		February 10, 1867	15·8	C. H.
Gold-silver alloy ...	10	January 5, 1865	15·6	A. M.
		February 10, 1867	15·6	C. H.
Gold-silver alloy ...	58	April 10, 1865	15·3	A. M.
		June 6, 1865	15·3	A. M.
		February 10, 1867	15·3	C. H.
Platinum	35	January 7, 1865	15·7	C. H.
		August 18, 1866	15·7	A. M.
		February 10, 1867	15·7	C. H.
Platinum	36	January 7, 1865	15·5	C. H.
		August 18, 1866	15·5	A. M.
		February 10, 1867	15·7	C. H.
Platinum-silver alloy......	43	February 15, 1865	15·2	C. H.
		March 9, 1865	15·2	A. M.
		February 10, 1867	15·2	C. H.
*Mercury	I.	February 2, 1865	16·0	A. M.
		July 18, 1866	16·0	A. M.
		February 11, 1867	16·7	C. H.
Mercury....................	II.	February 3, 1865	14·8	A. M.
		August 18, 1866	14·8	A. M.
		February 11, 1866	14·8	C. H.
Mercury	III.	February 11, 1867	17·9	C. H.

* The alteration of this coil, observed on February 11, 1867, is due, no doubt, to a defect observed in the glass tube.

The tube was of lead-glass. Perhaps the strong nitric acid used to clean the tube attacked the glass. A new mercury unit (No. III.) was made in consequence of this defect.

The apparent alteration in the platinum-iridium coils from the first value found, I believe to be owing to a clerical error. No alteration has been observed in them since the second observation made by Dr. Matthiessen in June 1865.

The values given in the above Table are deduced from the German-silver coil called B, used in your Committee's experiments in 1864 This coil was found (by comparison with copies made in 1864, of gold-silver, German silver, and platinum silver) not to have altered. The coil B was also compared with the coil (June 4) used in 1863, and the ratio of the two coils was found not to have altered.

IV. *Experiments on Capacity.* *By* Fleeming Jenkin, *F.R.S.*

The capacity of a condenser made of mica and tinfoil was adjusted so as to be approximately equal to 10^{-14} electromagnetic absolute units, according

to the following experiments. The capacity of any condenser can be directly measured in absolute measure by the following formula applying to the effect of a single discharge from the condenser through a galvanometer:—

$$S = 2\frac{t \sin \frac{1}{2} i}{\pi R_1}$$

(*vide* Report, 1863, Appendix C, p. 144), where R_1 is the resistance of a circuit in which the electromotive force used to charge the condenser would produce the unit deflection, while i is the angle to which the needle is observed to swing from a position of rest, and is half the period or time of a complete oscillation of the needle of the galvanometer under the influence of terrestrial magnetism alone.

This formula, which is analogous to that for any ballistic pendulum acted upon by a known impulse, supposes that the whole impulse is given in a time very short as compared with t, and it also supposes that the deflection i is unimpeded by friction.

I employed a Thomson's astatic reflecting galvanometer with double coils of German-silver wire. The oscillations, with the usual mirror and magnet, subside so rapidly that t cannot be measured with accuracy, and i is very sensibly affected by the resistance of the air; to obviate this I attached a brass ball to the lower magnet of the galvanometer, weighing 55 grains*.

A single floss-silk fibre can just support this weight, under which it continues to stretch sensibly for about three days. In order that the discharge from the condenser, electrified by from 20 to 30 cells, should have force to move this heavy ball through a sensible angle, the galvanometer was made highly astatic, and then I found that with even a single cocoon fibre the needle did not return to zero within three or four divisions of the scale for some minutes, exhibiting a kind of viscosity. The floss-silk fibre, though much weaker, gave a very constant zero. The value of t with the weighted needle seldom differed much from 20 seconds, and the times could be observed for 10 or 11 minutes, during which time t was found to remain sensibly constant. As there was no difficulty in observing the times of oscillation within one second, it may be said that the observed value of t was correct within one part in 500. Greater accuracy was not required, as the possible error from other sources considerably exceeds this. Twenty Daniell's cells were used to charge the condenser, and the discharge observed was about 180 divisions; but the observations were recorded within a quarter of a division: as this is done by estimating the position of the reflected spot stationary between the two black lines of the scale for an almost insensible time, it would not be right to assume that the deflection i is observed with greater accuracy than one part in 400. When the spot of light returned after making one complete oscillation, the diminution in the deflection was from 10 to 12 divisions; one quarter of this amount was therefore added as correction in each case to the deflection observed. The resistance of the whole circuit was composed of the battery resistance, that of German-silver resistance-coils, and of the German-silver coils in the galvanometer; no considerable variation could therefore occur except in the battery, which formed only a small portion of the total resistance. The coils (adjusted by Mr. Hockin) are probably correct within one part in a thousand, and the measurement of the galvanometer-coils is equally well known.

From what has been said, it might be expected that the capacity of any condenser could be obtained with an accuracy of one part in 400 or 500 at

* The ball, two magnets, mirror, and connecting bar, forming the whole suspended system, weighed 57½ grains.

least; but successive discharges were occasionally found to differ by as much as two divisions, though this amount of discrepancy was rare. It was due partly to the residual effect of former charges in the condenser, though great care was taken to avoid this, partly, it is believed, to slight changes in the electromotive force of the battery (which was not in very good order, the discharges being generally less toward the end of a set of experiments), and partly to slight motion of the needle at the moment of taking the discharge. This last source of error made it impossible to make the observations in London; even in the country the needle was seldom, if ever, absolutely still, though the oscillations were generally less than one division. The variation of the electromotive force and resistance of the battery when taking a permanent deflection was another source of error. Owing to the great inertia of the swinging parts, no observation could be taken until the current had been flowing for at least a minute, and often more; and, especially when small resistances were used, the deflections visibly diminished with time. Owing to all these causes, I do not depend on the results obtained as certainly accurate within less than one per cent. This is the less to be regretted, as the capacity of a mica condenser is very ill defined within wide limits, owing to absorption.

The condenser used consisted of 38 plates of mica, about 0·003 in. thick, and having a circular piece of tinfoil 3 in. in diameter cemented to each side of the mica, with a piece of each tinfoil projecting beyond the mica so as to join all the upper tinfoils and all the lower tinfoils together, and form the inner and outer armature of the condensers. This plan has for some time been practised by Mr. Latimer Clark, and makes a very constant and well-insulated condenser, extremely easy to adjust roughly by altering the number of the mica plates, and for small corrections by cutting away portions of the tinfoil from the top plate. Mica, like all other solid dielectrics with which I am acquainted, apparently absorbs electricity to a very large extent, and continues to do so for a long time, discharging it at first rapidly, but at the last very slowly indeed, so that a complete discharge is not effected for hours. The total capacity of the condenser varies therefore as the time varies during which it is charged, and the apparent discharge varies with the time during which we measure it; for instance, if we merely observe the discharge due to a momentary contact, we shall obtain a different result from that given when we maintain the contact all the time the needle is swinging; the result will also vary in the latter case with the time of oscillation of the galvanometer needle. If the needle oscillates slowly, it will be acted upon by a greater quantity of electricity than if oscillating rapidly. Thus, in one experiment, the deflection, when the discharging contact was permanently maintained, was 166 divisions, when a momentary contact was made by a blow it was only 156°. When the contact was made for about 1·7 second the deflection was 161, and when the contact was maintained for 3·4 seconds the deflection was 164; the maximum deflection of 166 was reached after 5 seconds: these experiments show that when the needle had travelled two-thirds of its maximum distance, the current being discharged exercised a very sensible influence on the deflection. The ballistic formula is therefore not strictly applicable to a case of this kind, and a different result would be obtained with a galvanometer oscillating either more or less quickly than the one I used. It seemed therefore unnecessary to take great precautions or to aim at any high degree of accuracy; and my object has simply been to provide a unit for cable-testing which shall be approximately equal to the ideal standard chosen by the Committee, and which can be used with at least as great accuracy as those copies of knots of Atlantic or Persian Gulf cables hitherto used.

The value of R_1, in the formula given at the commencement, was found by two methods, which we will call the indirect and direct method. In the indirect method three sets of resistance-coils, a, b, c, were arranged as in fig. 1, with a battery B, and a galvanometer G, and a shunt Z, equal

Fig. 1.

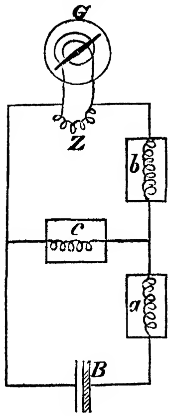
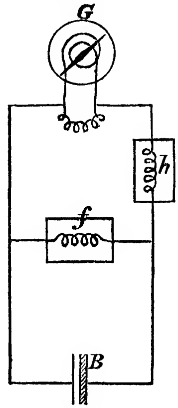


Fig. 2.



in resistance to $\frac{1}{999}$ of the galvanometer-coils. The resistance c was made equal to 1000 units, and the resistances a and b adjusted until a convenient deflection was obtained on the galvanometer; the resistance a was next changed to a_1, and b was then altered to b_1, so as to give the same deflection as before on the galvanometer G. Then calling d the deflection observed, G the resistance of the galvanometer, we have

$$R_1 = nd\left\{(a_1-a)\frac{(b+c+\frac{1}{n}G)\,(b_1+c+\frac{1}{n}G)}{(b-b_1)\,c}-c\right\},$$

a formula for which the resistance of the battery need not be calculated ($n=1000$).

The second or direct method of obtaining R_1 was first to calculate the resistance of the battery B by the following formula (fig. 2):—h and f are variable resistances; g the resistance of the shunted galvanometer $=47{\cdot}2$ in my experiments; break the circuit at f, and adjust h till a convenient reading is obtained; then join f, as shown in the sketch, and adjust f and h until the same deflection is obtained as before; then, calling h_1 the last resistance at h, we have

$$B=f\frac{h-h_1}{g+h_1}.$$

Secondly, a direct deflection d was obtained with a resistance k in circuit; then $R_1=nd\,(k+B+g)$.

The following is a record of the experiments made in chronological order:—

September 22.—*Discharge.*—Values of i after charging for one minute with 20 cells:—

1°.	2°.	3°.	4°.	5°.	Mean.
167	167	166	165	165	166

Adding 2·5 to compensate for portion of air $i=168{\cdot}5$, and the angle being very small, $\sin\frac{1}{2}i=84{\cdot}25$.

Test for insulation; discharge after one minute's insulation 154.

Times.—First four oscillations; the spot crossed the central point in the same direction at

0′ 35″, 0′ 55″, 1′ 14½″, 1′ 33″;

last four oscillations,

9′ 13″, 9′ 32″, 10′ 10″, 10′ 29″.

Total number of oscillations 31. Mean value of $2t$=19′ 15″.

Value of R_1. Indirect method:—

	a.	a_1.	*b.*	b_1.	*c.*	*d.*	R_1 Ohm's.
1°....	8000	10000	1000	649	1000	275½	$5·17 \times 10^9$
2°....	6000	8000	1000	575	1000	354½	5·17 „
3°....	8000	10000	1000	647	1000	274½	5·12 „
4°....	6000	8000	1000	574	1000	355¼	5·18 „

Mean value of R_1 in absolute measure $5·16 \times 10^{16}$. Value of S, $99·53 \times 10^{-12}$.

Value of R_1. Direct method. Battery resistance:—

	f.	*h.*	h_1.	*g.*	B.	
1°....	2	18700	30	47	484	Mean value of B 488.
2°....	10	18000	300	47	492	

Deflection with variable resistance in circuit:—

	d.	*k.*	B	*g.*	*n.*	R_1 Ohm's.
1°....	226½	22000	488	47	1000	$5·10 \times 10^9$
2°....	310¼	16000	488	47	1000	$5·13 \times 10^9$

Mean value of $R_1=5·125 \times 10^{16}$ absolute units. Value of S from values of t and i as above, $100·21 \times 10^{-14}$.

September 24.—*Discharge.*—sin ½ i=84·75. R_1 from indirect method:—

	a.	a_1.	*b.*	b_1.	*c.*	*d.*	R_1 Ohm's.
1°....	6000	8000	1000	575	1000	354	$5·18 \times 10^9$
2°....	8000	10000	1000	648	1000	275	$5·16 \times 10^9$

Mean value of R_1 in absolute measure $5·17 \times 10^6$. Assuming t as on September 23, $S=99·92 \times 10^{-12}$.

The box holding the condenser was now filled up with an insulating composition.

October 13.—*Discharge.*—184 divisions, 12 divisions lost on return, sin ½ i=93·5. Discharge after one minute's insulation 181 divisions.

Time.—First four oscillations,

0′ 30″, 0′ 51″, 1′ 11″, 1′ 31″;

last four oscillations,

10′ 4″, 10′ 23″, 10′ 43½″, 11′ 5″.

Total number of oscillations 31. Mean value of $2t$=20·47.

R_1 by indirect method:—

a.	a_1.	*b.*	b_1.	*c.*	*d.*	R_1.
8000	10000	1000	646	1000	333	$6·19 \times 10^9$.

Value of $S=98·42 \times 10^{-12}$.

R_1 by direct method. Battery resistance:—

f.	*h.*	h_1.	*g.*	B.
10	17400	700	47	223½

Direct deflection:—

	d.	*k.*	B.	*g.*	*n.*	R_1.
1°....	270½	22000	223½	47	1000	$6·01 \times 10^9$
2°....	331	18000	223½	47	1000	$6·05 \times 10^9$

Mean value of $R_1=6·03 \times 10^{16}$ absolute units. Value of $S=101·03 \times 10^{-12}$.

October 15.—*Discharge*:—

1°.	2°.	3°.	4°.	5°.	6°.
185	185	184½	184	184½	184¾

Mean 184·6, adding 3 for air, sin ½ i=93·8.

Times.—First four, 0′ 23″, 0′ 42½″, missed, 1′ 24″; last four, 7′ 55″, 8′ 16″, 8′ 35″, 24 oscillations in all. Mean value of $2t$=20·56.

Independent series of observations divided into triplets:—

first two, 0′ 22½, 1′ 24″, last two, 9′ 37½, 10″·39,

30 oscillations in all. Mean value of $2t=20·55$.

Value of R_1. Direct method. Battery resistance:—

1°	223
2°	216
Mean	219

Direct deflection:—

	d.	k.	B.	g.	n.	R_1 Ohm's.
1°	278	22000	219	47	1000	$6·19 \times 10^9$
2°	321½	19000	219	47	1000	$6·19 \times 10^9$

Mean value of R_1 in absolute units $6·19 \times 10^{19}$. Value of $S=99·2 \times 10^{-12}$.

October 17.—*Discharge*:—

1°.	2°.	3°.	4°.	Mean.
179	180	179	180	179·5

$\sin \tfrac{1}{2} i = 91\tfrac{1}{4}$.

Times:—

0′ 55″, 1′ 56½″, 10′ 7½″, 11′ 8½″.

Total number of oscillations 30. Mean value of $2t=20·46$.

Value of R_1. Direct method. Battery resistance:—

1°	210
2°	223
Mean	215·5

Direct deflection.:—

	d.	k.	B.	g.	n.	R_1 Ohm's.
1°	268	22000	215½	47	1000	$5·97 \times 10^9$
2°	329	18000	215½	47	1000	$6·01 \times 10^9$

Mean value of $R_1 = 5·99 \times 10^{19}$ absolute units. Value of $S=99·25$.

The seven values obtained for S give a mean value of $·9965 \times 10^{-14}$ as the capacity of the mica-plate condenser when charged for one minute, and measured by a discharge through a galvanometer, on the needle of which it acts for about 5 seconds. If we reject the two observations made on Oct. 15, which were, indeed, only preliminary, and made with less care than all the others, we find the average to be $0·9962 \times 10^{-14}$ and the approximation between this mean and any single results is 0·42 per cent. It is therefore probable that a unit copied from this preliminary standard will not be one per cent. wrong.

A tenfold multiple (10^{-13} absolute measure) of the condenser measured is a convenient magnitude as a practical unit of capacity for telegraphy; thus the capacity of the Atlantic cable per knot thus measured is 0·3535. Assuming that the practical unit of electromotive force will be chosen as that multiple which is most nearly equal to Daniell's cell, *i. e.* 10^5 electromagnetic units, then the capacity of the proposed practical unit is such that it contains with the unit E M F the same quantity of electricity as would be passed in one second through a circuit of the resistance of one Megohm. Thus 10^5 E M F, acting on a circuit of 10^{13}, will pass in one second 10^{-8} absolute units of quantity; and similarly, 10^5 E M F will charge a condenser of absolute capacity equal to 10^{-13} with 10^{-8} absolute units of quantity. This practical series of units is that which, in the opinion of Mr. Latimer Clark and myself, is best adapted for practical use in telegraphy. Mr. Clark calls the unit of quantity thus defined (10^{-8}) one Farad, and similarly says that the unit of capacity has a capacity of one Farad, it being understood that this is the capacity when charged with unit electromotive force (10^5).

V. *Report on Electrometers and Electrostatic Measurements.* *By* Sir Wm. Thomson, *F.R.S.*

§ 1. An electrometer is an instrument for measuring differences of electric potential between two conductors through effects of electrostatic force, and is distinguished from the galvanometer, which, of whatever species, measures differences of electric potentials through electromagnetic effects of electric currents produced by them. When an electrometer merely indicates the existence of electric potential, without measuring its amount, it is commonly called an electroscope; but the name electrometer is properly applied when greater or less degrees of difference are indicated on any scale of reckoning, if approximately constant, even during a single series of experiments. The first step towards accurate electrometry in every case is to deduce from the scale-readings numbers which shall be in simple proportion to the difference of potentials to be determined. The next and last step is to assign the corresponding values in absolute electrostatic measure. Thus, when for any electrometer the first step has been taken, it remains only to determine the single constant coefficient by which the numbers deduced from its indications as simply proportional to differences of potential must be multiplied to give differences of potential in absolute electrostatic measure. This coefficient will be called, for brevity, the absolute coefficient of the instrument in question.

§ 2. Thus, for example, the gold-leaf electrometer indicates differences of potential between the gold leaves and the solid walls enclosing the air-space in which they move. If this solid be of other than sufficiently perfect conducting material, of wood and glass, or of metal and glass, for instance, as in the instrument ordinarily made, it is quite imperfect and indefinite in its indications, and is not worthy of being even called an electroscope, as it may exhibit a divergence when the difference of potentials which the operator desires to discover is absolutely zero. It is interesting to remark that Faraday first remedied this defect by coating the interior of the glass case with tinfoil cut away to leave apertures proper and sufficient to allow indications to be seen, but not enough to cause these indications to differ sensibly from what they would be if the conducting envelope were completely closed around it; and that not till a long time after did any other naturalist, mathematician, or instrument-maker seem to have noticed the defect, or even to have unconsciously remedied it.

§ 3. Electrometers may be classified in genera and species according to the shape and kinematic relations of their parts; but as in plants and animals a perfect continuity of intermediate species has been imagined between the rudimentary plant and the most perfect animal, so in electrometers we may actually construct species having intermediate qualities continuous between the most widely different genera. But, notwithstanding, some such classification as the following is convenient with reference to the several instruments commonly in use and now to be described:—

I. Repulsion electrometers.
- Pair of diverging straws as used by Beccaria, Volta, and others, last century.
- Pair of diverging gold leaves (Bennet).
- Peltier's electrometer.
- Delmann's electrometer.
- Old-station electrometer, described in lecture to the Royal Institution, May 1860; also in Nichol's Cyclopædia, article "Electricity, Atmospheric" (edition 1860), and in Dr. Everett's

paper of 1867, "On Atmospheric Electricity" (Philosophical Transactions).

II. Symmetrical electrometers.
    Bohnenberger's electrometer.
    Divided-ring electrometers.

III. Attracted disk electrometers.
    Absolute electrometer.
    Long-range electrometer.
    Portable electrometer.
    Spring-standard electrometer.

§ 4. Class I. is sufficiently illustrated by the examples referred to; and it is not necessary to explain any of these instruments minutely at present, as they are, for the present at all events, superseded by the divided-ring electrometer and electrometers of the third class.

There are at present only two known species of the second class; but it is intended to include all electrometers in which a symmetrical field of electric force is constituted by two symmetrical fixed conductors at different electric potentials, and in which the indication of the force is produced by means of an electrified body moveable symmetrically in either direction from a middle position in this field. This definition is obviously fulfilled by Bohnenberger's well-known instrument*.

§ 5. My first published description of a divided-ring electrometer is to be found in the Memoirs of the Roman Academy of Sciences† about 1856; but since that time I have made great improvements in the instrument—first, by applying a light mirror to indicate deflections of the moving body; next, by substituting for two half rings four quadrants, and consequently for an electrified body projecting on one side only of the axis, an electrified body projecting symmetrically on the two sides, and moveable round an axis; and lastly, by various mechanical improvements and by the addition of a simple gauge to test the electrification of the moveable body, and a replenisher to raise this electrification to any desired degree.

§ 6. In the accompanying drawings, Plate V. fig. 1 represents the front elevation of the instrument, of which the chief bulk consists of a jar of white glass (flint) supported on three legs by a brass mounting, cemented round the outside of its mouth, which is closed by a flat cover of stout sheet-brass, and a lantern-shaped cover standing over a wide aperture in its centre. For brevity, in what follows these three parts will be called the jar, the main cover, and the lantern.

Fig. 5 represents the quadrants as seen from above; they are seen in elevation at *a* and *b*, fig. 1, and in section at *c* and *d*, fig. 2. They consist of four quarters of a flat circular box of brass, with circular apertures in the centres of its top and bottom. Their position in the instrument is shown in figs. 1, 2, & 6. Each of the four quadrants is supported on a glass stem passing downwards through a slot in the main cover of the jar, from a brass mounting on the outside of it, and admits of being drawn outwards for a space of about $\frac{3}{8}$ of an inch (1 centim.) from the positions they occupy when the instrument is in use, which are approximately those shown in the drawings. Three of them are secured in their proper positions by nuts (*e*, *e*, *e*) on the outside of the chief flat lid of the jar shown in fig. 4. The upper end of the stem, carrying the fourth, is attached to a brass piece (*f*) resting on three short legs

* A single gold leaf hanging between the upper ends of two equal and similar dry piles standing vertically on a horizontal plate of metal, one with its positive and the other with its negative pole up.

† Accademia Pontificia dei Nuovi Lincei.

on the upper side of the main cover, two of these legs being guided by a straight V-groove at g to give them freedom to move in a straight line inwards or outwards, and to prevent any other motion. This brass piece is pressed outwards and downwards by a properly arranged spring (h), and is kept from sliding out by a micrometer-screw (i) turning in a fixed nut. This simple kinematic arrangement gives great steadiness to the fourth quadrant when the screw is turned inwards or outwards, and then left in any position; and at the same time produces but little friction against the sliding in either direction. The opposite quadrants are connected in two pairs by wires, as shown in fig. 5; and two stout vertical wires (l, m), called the chief electrodes passing through holes in the roof of the lantern, are firmly supported by long perforated vulcanite columns passing through those holes which serve to connect the pairs of quadrants with the external conductors whose difference of potentials is to be tested. Springs (n, o) at the lower ends of these columns, shown in figs. 1 & 2, maintain metallic contact between the chief electrodes and the upper sides of two contiguous quadrants (a & b) when the lantern is set down in its proper position, but allow the lantern to be removed, carrying the chief electrodes with it, and to be replaced at pleasure without disturbing the quadrants. The lantern also carries an insulated charging-rod (p), or temporary electrode, for charging the inner coating of the jar (§ 11) to a small degree, to be increased by the replenisher (§ 12), or, it may be, for making special experiments in which the potential of the interior coating of the jar is to be measured by a separate electrometer, or kept at any stated amount from that of the outer coating. When not in use this temporary electrode is secured in a position in which it is disconnected from the inner coating.

§ 7. The main cover supports a glass column (q, fig. 2) projecting vertically upwards through its central aperture, to the upper end of which is attached a brass piece (r), which bears above it a fixed attracting disk (s), to be described later (§ 13); and projecting down from it a fixed plate bearing the silk-fibre suspension of the mirror (t), needle (u), &c., seen in figs. 1 & 2, and fixed guard tubes (v, w), to be described presently.

§ 8. The moveable conductor of the instrument consists of a stiff platinum wire (x), about 8 centimetres ($3\frac{1}{8}$ inches) long, with the needle rigidly attached in a perpendicular plane to it, and connected with sulphuric acid in the bottom of the jar by a fine platinum wire hung down from its lower end and kept stretched by a platinum weight under the level of the liquid. The upper end of the stiff platinum wire is supported by a single silk-fibre so that it hangs down vertically. The mirror is attached to it just below its upper end. Thus the mirror, the needle, and the stiff platinum stem constitute a rigid body having very perfect freedom to move round a vertical axis (the line of the bearing fibre), and yet practically prevented from any other motion in the regular use of the instrument by the weight of its own mass and that of the loose piece of platinum hanging from it below the surface of the liquid in the jar. A very small magnet is attached to the needle, which, by strong magnets fixed outside the jar, is directed to one position, about which it oscillates after it is turned through any angle round the vertical axis, and then left to itself. The external magnets are so placed that when there is magnetic equilibrium the needle is in the symmetrical position shown in figs. 5 & 6 with reference to the quadrants *.

§ 9. The needle (u) is of very thin sheet aluminium cut to the shape seen in figs. 5 & 6; the very thinnest sheet aluminium that gives the requisite stiff-

* Recently I have made experiments on a bifilar suspension with a view to superseding the magnetic adjustment, which promise well.

ness being chosen. If the four quadrants are in a perfectly symmetrical position round it, and if they are kept at one electric potential by a metallic arc connecting the chief electrodes outside, the needle may be strongly electrified without being disturbed from its position of magnetic equilibrium; but if it is electrified, and if the external electrodes be disconnected, and any difference of potentials established between them, the needle will clearly experience a couple turning it round its vertical axis, its two ends being driven from the positive quadrants towards the negative, if it is itself positively electrified. It is kept positive rather than negative in the ordinary use of the instrument, because I find that when a conductor with sharp edges or points is surrounded by another presenting everywhere a smooth surface, a much greater difference of potentials can be established between them, without producing disruptive discharge, if the points and edges are positive than if they are negative.

§ 10. The mirror (t) serves to indicate, by reflecting a ray of light from a lamp, small angular motions of the needle round the vertical axis. It is a very light, concave, silvered glass mirror, being of only 8 millimetres ($\frac{1}{3}$ of an inch) diameter, and 22 milligrammes ($\frac{1}{3}$ grain) weight. I had for many years experienced great difficulty in getting suitable mirrors for my form of mirror galvanometer; but they are now supplied in very great perfection by Mr. Becker, of Messrs. Elliott Brothers, London. The focus for parallel rays is about 50 centimetres (20 inches) from the mirror, and thus the rays of the lamp placed at a distance of 1 metre (or 40 inches) are brought to a focus at the same distance. The lamp is usually placed close behind the vertical screen a little below or above the normal line of the mirror, and the image is thrown on a graduated scale extending horizontally above or below the aperture in the screen through which the lamp sends its light. When the mirror is at its magnetic zero position the lamp is so placed that its image is, as nearly as may be, in a vertical plane with itself, and not more than an inch above or below its level, so that there is as little obliquity as possible in the reflection, and the line traversed by the image on the screen during the deflection is, as nearly as may be, straight. The distance of the lamp and screen from the mirror is adjusted so as to give as perfect an image as possible of a fine wire which is stretched vertically in the plane of the screen across the aperture through which the lamp shines on the mirror; and with Mr. Becker's mirrors I find it easy to read the horizontal motions of the dark image to an accuracy of the tenth of a millimetre. In the ordinary use of the instrument a white paper screen, printed from a copper-plate, is employed, and the readings are commonly taken to about a quarter of a scale-division; but with a little practice they may, when so much accuracy is desired, be read with considerable accuracy to the tenth of a scale-division. Formerly a slit in front of the lamp was used, but the wire giving a dark line in the middle of the image of the flame is a very great improvement, first introduced by Dr. Everett in consequence of a suggestion made by Professor P. G. Tait, in his experiments on the elasticity of solids made in the Natural-Philosophy Laboratory of Glasgow University*.

§ 11. The charge of the needle remains sensibly constant from hour to hour, and even from day to day, in virtue of the arrangement, according to which it is kept in communication with sulphuric acid in the bottom of the

* A Drummond light placed about 70 centimetres from the mirror gives an image, on a screen about 3 metres distance, brilliant enough for lecture-illustrations, and with sufficient definition to allow accurate readings of the positions on a scale marked by the image of a fine vertical wire in front of the light.

jar, the outside of the jar being coated with tinfoil and connected with the earth, so that it is in reality a Leyden jar. The whole outside of the jar, even where not coated with tinfoil, is in the ordinary use of the instrument, especially in our moist climate, kept virtually at one potential through conduction along its surface. This potential is generally, by connecting wires or metal pieces, kept the same as that of the brass legs and framework of the instrument. To prevent disturbance in case of strongly electrified bodies being brought into the neighbourhood of the instrument, a wire is either wrapped round the jar from top to bottom, or a cage or network of wire, or any convenient metal case, is placed round it; but this ought to be easily removed or opened at any time to admit of the interior being seen. When the instrument is left to itself from day to day in ordinary use, the needle, connected with the inner coating of the jar as just described, loses, of course, unless replenished, something of its charge; but not in general more than $\frac{1}{2}$ per cent. per day, when the jar is of flint glass made in Glasgow. On trying similar jars of green glass I found that they lost their charge more rapidly per hour than the white glass jars per month. I have occasionally, but very rarely, found white glass jars to be as defective as those green ones, and it is possible that the defect I found in the green jars was an accident to the jars tested, and not an essential property of that kind of glass.

§ 12. I have recently made the very useful addition of a replenisher to restore electricity to the jar from time to time when required. It consists of (1) a turning vertical shaft of vulcanite bearing two metal pieces called carriers (*b*, *b*, figs. 17 & 18); (2) two springs (*d*, *d*, figs. 16 & 18, Plate V.), connected by a metallic arc, making contact on the carriers once every half turn of the shaft, and therefore called connectors; and (3) two inductors (*a*, *a*) with receiving springs (*c*, *c*) attached to them, which make contact on the carriers once every half turn, shortly before the connecting contacts are made. The inductors (*a a*, figs. 16 & 18) are pieces of sheet metal bent into circular cylindrical shapes of about 120° each; they are placed so as to deviate in the manner shown in the drawing from parts of a cylindrical surface coaxal with the turning-shaft, leaving gaps of about 60° on each side. The diameter of this cylindrical surface is about 15 millimetres (about $\frac{1}{2}$ an inch). The carriers (*b b*, figs. 17 & 18) are also of sheet metal bent to cylindrical surfaces, but not exactly circular cylinders; and are so placed on the bearing vulcanite shaft that each is rubbed by the contact springs over a very short space, about 1 millimetre beyond its foremost edge, when turned in the proper direction for replenishing. The receiving springs (*c*, *c*, figs. 17 & 18) make their contacts with each carrier immediately after it has got fairly under cover, as it were, of the inductor. Each carrier subtends an angle of about 60° at the axis of the turning-shaft. The connecting contacts are completed just before the carriers commence emerging from being under cover of the inductors. The carriers may be said to be under cover of the inductors when they are within an angle of 120° on each side of the axis subtended by the inductors. One of the inductors is in metallic communication with the outside coating of the jar, the other with the inside. Figs. 16, 17, & 18 illustrate sufficiently the shape of carriers and the succession of the contacts. The arrow-head indicates the direction to turn for replenishing. When it is desired to diminish the charge, the replenisher is turned backwards. A small charge having been given to the jar from an independent source, the replenisher when turned forwards increases the difference of potentials between the two inductors and the two coatings of the jar connected with them by a constant percentage per half turn, unless it is raised to so high a degree as to break

down the air-insulation by disruptive discharge. The electric action is explained simply thus:—The carriers, when connected by the connecting springs, receive opposite charges by induction, of which they deposit large proportions the next time they touch receiving springs. Thus, for example, if the jar be charged positively, the carrier emerging from the inductor connected with the inner coating carries a negative charge round to the receiving spring connected with the outside coating, while the other carrier, emerging from the inductor connected with the outside coating, carries a positive charge round to the receiving spring connected with the inside coating. If the carriers are not sufficiently well under cover of the inductors during both the receiving contacts and the connecting contacts to render the charges which they acquire by induction during the connecting contacts greater than that which they carry away with them from the receiving contacts, the rotation, even in the proper direction for replenishing, does not increase, but, on the contrary, diminishes the charge of the jar. The deviations of the inductors from the circular cylinder referred to above have been adopted to give greater security against this failure. A steel pivot fixed to the top of the vulcanite shaft, and passing through the main cover, carries a small milled head (y, fig. 1) above, on the outside, which is spun rapidly round in either direction by pressing the finger on it, and thus in less than a minute a small charge in the jar may be doubled. The diminution of the charge, when the instrument is left to itself for twenty-four hours, is sometimes imperceptible; but when any loss is discovered to have taken place, even if to the extent of 10 per cent., a few moments use of the replenisher suffices to restore it, and to adjust it with minute accuracy to the required degree by aid of the guage to be described presently. The principle of the "replenisher" is identical with that of the "doubler" of Bennet. In the essentials of its construction it is the same as Varley's improved form of Nicholson's "revolving doubler."

§ 13. The gauge consists of an electrometer of Class III. The moveable attracted disk is a square portion of a piece of very thin sheet aluminium of the shape shown at x in fig. 4. It is supported on a stretched platinum wire passing through two holes in the sheet, and over a very small projecting ridge of bent sheet aluminium placed in the manner shown in the magnified drawing, fig. 3. The ends of this wire are passed through holes in curved springs, shown in fig. 4, and are bent round them so as to give a secure attachment without solder, and without touching the straight stretched part of the wire. The ends of the platinum wire (β, β) are attached by cement to the springs, merely to prevent them from becoming loose, care being taken that the cement does not prevent metallic contact between some part of the aluminium wire and one or both of the brass springs. I have constantly found fine platinum wire rendered brittle by ordinary solder applied to it. The use of these springs is to keep the platinum wire stretched with an approximately constant tension, from year to year and at various temperatures. Their fixed ends are attached to round pins, which are held with their axes in a line with the fibre by friction, in bearings forming parts of two adjustable brass pieces (γ, γ) indicated in fig. 4; these pieces are adjusted once for all to stretch the wire with sufficient force, and to keep the square attracted disk in its proper position. The round pins bearing the stretching springs are turned through very small angles by pressing on the projecting springs with the finger. They are set so as to give a proper amount of torsion tending to tilt the attracted disk (α) upwards, and the long end of the aluminium lever (δ), of which it forms a part, downwards. The downward motion of the long end

is limited by a properly placed stop. Another stop (ϵ) above limits the upward motion, which takes place under the influence of electrification in the use of the instrument. A very fine opake black hair (that of a small black-and-tan terrier I have found much superior to any hitherto tried) is stretched across the forked portion of the sheet aluminium in which the long arm of the lever terminates. Looked at horizontally from the outside of the instrument it is seen, as shown in fig. 7, Plate V., against a white background, marked with two very fine black circles. These sight-plates in the instruments, as now made by Mr. White, are of the same material as the ordinary enamel watch-dials, with black figures on a white ground. The white space between the two circles should be a very little less than the breadth of the hair. The sight-plate is set to be as near the hair as it can be without impeding its motion in any part of its range; and it is slightly convex forwards, and is so placed that the hair is nearer to it when in the middle between the black circles than when in any other part of its range. It is thus made very easy, even without optical aid, to avoid any considerable error of parallax in estimating the position of the hair relatively to the two black circles. By a simple plano-convex lens (ϕ, fig. 2), with the convex side turned inwards, it is easy, in the ordinary use of the instrument, to distinguish a motion up or down of the hair amounting to $\frac{1}{5000}$ of an inch. With a little care I have ascertained, Dr. Joule assisting, that a motion of no more than $\frac{1}{50,000}$ of an inch from one definite central position can be securely tested without the aid of other magnifying-power than that given by the simple lens. The lens during use is in a fixed position relatively to the framework bearing the needle, but it may be drawn out or pushed in to suit the focus of each observer. To give great magnification, it ought to be drawn out so far that the hair and sight-plate behind may be but little nearer to the lens than its principal focus, and the observer's eye ought to be at a very considerable distance from the instrument, no less than 20 centimetres (8 inches) to get good magnification; and a short-sighted person should use his ordinary concave eye-lens close to his eye. The reason for turning the convexity of the small plano-convex lens inwards is, that if the eye of the observer is too high or too low, the hair seems to him curved upwards or downwards, and he is thus guided to keep his eye on a level sufficiently constant to do away with all sensible effects of parallax on the position of the hair relatively to the black circles. The framework carrying the stretched platinum wire and moveable attracted disk is above the brass roof of the lantern, in which a square aperture is cut to allow the square portion constituting the short arm of the aluminium balance to be attracted downwards by the fixed attracting disk (§ 7), to be presently described. A side view of the attracting plate, the brass roof of the lantern, the aluminium balance, the sight-plate, the hair, and the plano-convex lens is shown in section (fig. 2), also a glass upper roof to protect the gauge and the interior of the instrument below from dust and disturbance by currents of air, to which, without this upper roof, it would be exposed, through the small vacant space round the moveable aluminium square. The fixed attracting disk is borne by a vertical screw screwing into the upper brass mounting (z, fig. 2) (§ 7), connected with the inner coating of the Leyden jar, through the guard tubes, &c., and is secured in any position by the "jam nut," shown in the drawings at z, fig. 2. This disk (s) is circular, and about 38 millimetres ($1\frac{1}{2}$ inch) diameter, and it is placed horizontally with its centre under the centre of the square aperture in the roof of the lantern. Its distance from the lower surface of the roof and of the moveable attracted disk may be from $2\frac{1}{2}$ to 5 millimetres (from $\frac{1}{10}$ to $\frac{1}{5}$ of an inch), and is to be adjusted,

along with the amount of torsion in the platinum wire bearing the aluminium balance-arm, so as to give the proper sensibility to the gauge. The sensibility is increased by diminishing the distance from the attracting to the attracted plate, and increasing the amount of torsion. Or, again, the degree of the potential indicated by it when the hair is in the sighted position is increased by increasing the distance between the plates, or by diminishing the amount of torsion. If the electrification of the needle is too great, its proper position of equilibrium becomes unstable; or before this there is sometimes a liability to discharge by a spark across some of the air-spaces. The instrument works extremely well with the needle charged but little less than to give rise to one or both of these faults, and I adjust the gauge accordingly.

§ 14. The strength of the fixed steel-directing magnets is to be adjusted to give the desired amount of deflection with any stated difference of potentials maintained between the two chief electrodes, when the jar is charged to the degree which brings the hair of the gauge to its sighted position. In the instruments already made, the deflection* by a single cell of Daniell's amounts to about 100 scale-divisions (of $\frac{1}{40}$ of an inch each at a distance of 40 inches), when the magnetic directive force is such as to give a period of vibration equal to about 1·5 second. When the jar is discharged and the four quadrants are connected with one another and with the inner coating of the jar, lower degrees of sensibility may be attained better by increasing the magnetic directing-force than by diminishing the charge of the jar. Thus, for instance, when it is to be used for measuring and photographically recording the potential of atmospheric electricity at the point where the stream of the water-dropping collector† breaks into drops, the magnetic directing-force may be made from 10 to 100 times more than that just described. When this is to be done it may be convenient to attach a somewhat more powerful magnetic needle than that which has been made in the most recent instruments where a high degree of sensibility is desired. But it is to be remarked that in general the directing-force of the external steel magnets cannot be too strong, as the stronger it is the less is the disturbance produced by changing magnetic bodies in the neighbourhood of the instrument. In laboratory work, where numerous magnetic experiments are being performed in the immediate neighbourhood, and in telegraph factories where there is constant disturbance by large moving masses of iron, the artificial magnetic field of the electrometer ought to be made very strong. To allow this, and yet leave sufficient sensibility to the instrument, the suspended magnetic needle has been made smaller and smaller, until it is now reduced to two small pieces of steel side by side, 6 millimetres ($\frac{1}{4}$ of an inch) long. For a meteorological observatory all that is necessary is, that the directing magnetic force should be so great that the greatest disturbance experienced in magnetic storms shall not sensibly deflect the luminous image ‡.

§ 15. The sensibility of the gauge should be so adjusted that a variation in the charge of the jar, producing an easily perceived change in the position of the hair, shall produce no sensible change in the deflection of the luminous image produced by the greatest difference of potentials between the quadrants, which is to be measured in the use of the instrument. I believe the

* That is to say, the number of scale-divisions over which the luminous image moves when the chief electrodes are disconnected from one another and put in metallic connexion with the two plates of a Daniell's battery.

† See Royal Institution Lecture, May 18, 1860 (Proceedings of the R. I.), or Nichol's Cyclopædia, article "Electricity, Atmospheric." (Edition 1860.)

‡ All embarrassment from this source will be done away with if the bifilar plan be adopted (*vide* footnote to § 8).

instruments already made, when adjusted to fulfil these conditions, may be trusted to measure the difference of potentials produced by a single cell of Daniell's to an accuracy of a quarter per cent. It must be remembered that the constancy of value of the unit of each instrument depends not only on the constancy of the potential indicated by the gauge, but also on the constancy of the force in the field traversed by the suspended needle. As both these may be expected to decrease gradually from year to year (although very slowly after the first few hours or weeks), rigorous methods must be adopted to take such variations into account, if the instrument is to be trusted to as giving accurately comparable indications at all times. The only method hitherto provided for this most important object consists in the observation of the deflection produced by a measured motion of one of the quadrants by the micrometer-screw (i) when the four quadrants are put in metallic communication with one another through the principal electrodes—the force producing this deflection when the potential of the jar is constant; and therefore, the jar being brought to one constant potential by aid of the gauge, the amount of the deflection will show whether or not the force of the magnetic field has changed, and will render it easy at any time to adjust the strength of the magnets, if necessary, to secure this constancy. But to attain this object by these means, the three quadrants not moved by the micrometer-screw must be clamped by their fixing-screws so that they may be always in the same position.

§ 16. The absolute constancy of the gauge cannot be altogether relied upon. It certainly changes to a sensible degree with temperature, and to very different degrees, and even in different directions, as will be seen (§ 32) in connexion with the description of the portable electrometer to be given later. But this temperature variation does not amount in ordinary cases probably to as much as one per cent.; and it is probable that after a year or two any further secular variation of the platinum torsion spring will be quite insensible. It is to be remarked, however, that secular experiments on the elasticity of metals are wanting, and ought at least to be commenced in our generation. In the meantime it will be desirable, both on account of the temperature variation and of the possible secular variation in the couple of torsion, to check the gauge by accurate measurements of the time of oscillation of the needle with its appurtenances. The moment of inertia of this rigid body, except in so far as it may be influenced by oxidation of the metal, of which I have as yet discovered no signs, may be regarded as constant, and therefore the amount of the directing couple due to the magnets may be determined with great accuracy by finding the period of an oscillation when the four quadrants are put in connexion through the charging rod with the metal mounting bearing the guard plates, &c. I have not as yet put into practice any of the obvious methods, founded on the general principle of coincidences used in pendulum observations, for determining the period of the oscillation; but although not more than twenty or thirty oscillations can be counted, it seems certain that with a little trouble the period of one of them may be determined without much trouble to an accuracy of about $\frac{1}{10}$ per cent.

Absolute Electrometer.

§ 17. The absolute electrometer (fig. 11, Plate VI.) and the other instruments of Class III. are founded on a method of experimenting introduced by Sir Wm. Snow Harris, and described in his first paper "On the Elementary Laws of Electricity" * thirty-four years ago. In these experiments a con-

* Philosophical Transactions, 1834.

ductor, hung from one arm of a balance and kept in metallic communication with the earth, is attracted by a fixed insulated conductor, which is electrified, and, for the sake of keeping its electric potential constant, is connected with the inner coating of a Leyden battery. The first result which he announced is, that, when other circumstances remain the same, the attraction varies with the square of the quantity of electricity with which the insulated body is charged; but "it is readily seen that, in the case of Mr. Harris's experi-
" ments, it will be so slight on the unopposed portions that it could not be
" perceived without experiments of a very refined nature, such as might
" be made by the proof plane of Coulomb, which is, in fact, with a slight
" modification, the instrument employed by Mr. Faraday in the investigation.
" Now to the degree of approximation to which the intensity on the unop-
" posed parts may be neglected, the laws observed by Mr. Harris when the
" opposed surfaces are plane may be readily deduced from the mathematical
" theory. Thus let v be the potential in the interior of A, the charged body,
" a quantity which will depend solely on the state of the interior coating
" of the battery with which, in Mr. Harris's experiments, A is connected,
" and will therefore be sensibly constant for different positions of A relative
" to the uninsulated opposed body B. Let a be the distance between the
" plane opposed faces of A and B, and let S be the area of the opposed parts
" of these faces, which will in general be the area of the smaller, if they be
" unequal. When the distance a is so small that we may entirely neglect
" the intensity on all the unopposed parts of the bodies, it is readily shown,
" from the mathematical theory, that (since the difference of the potentials at
" the surfaces of A and B is v) the intensity of the electricity produced by
" induction at any point of the portion of the surface of B which is opposed
" to A is $\frac{v}{4\pi a}$, the intensity at any point which is not so situated being
" insensible. Hence the attraction on any small element ω, of the portion S
" of the surface of B, will be in a direction perpendicular to the plane and
" equal to $2\pi\left(\frac{v}{4\pi a}\right)^2$*. Hence the whole attraction on B is

$$\frac{v^2 S}{8\pi a^2}.$$

" This formula expresses all the laws stated by Mr. Harris as results of his
" experiments in the case when the opposed surfaces are plane" †.

§ 18. After many trials to make an absolute electrometer founded on the repulsion between two electrified spherical conductors for which I had given a convenient mathematical formula in § 4 of the paper just quoted, it occurred to me to take advantage of the fact noticed by Harris, but easily seen as an immediate consequence of Green's mathematical theory, that the mutual attraction between two conductors used as in his experiments is but little influenced by the form of the unopposed parts; and in 1853, in a paper "On transient Electric Currents" ‡, I described a method for measuring differences of electric potential in absolute electrostatic measure founded on that idea. The "absolute electrometer," which I exhibited to the British Association at its Glasgow Meeting in 1855, was constructed for the purpose of putting these methods in practice. This instrument consists of a plane metal disk insulated in a fixed horizontal position with a somewhat smaller fixed metal

* See Mathematical Journal, vol. iii. p. 275.

† "On the Elementary Laws of Statical Electricity," Cambridge and Dublin Mathematical Journal, 1846; and Phil. Mag. July 1854.

‡ Phil. Mag. June 1853.

disk hung centrally over it, from one end of the beam of a balance. In two papers entitled "Measurement of Electostatic Force produced by a Battery" and "Measurement of the Electromotive Force required to produce a spark in Air between parallel metal plates at different distances," published in the Proceedings of the Royal Society* for February 1860, I described applications of this electrometer, in which, for the first time I believe, absolute electrostatic measurements were made. The calculations of differences of potentials in absolute measure were made according to the formula quoted above (§ 17) from my old paper on "The Elementary Laws of Statical Electricity."

§ 19. This formula is rigorous only if the distance between the disks is infinitely small in comparison with their diameters; and therefore, in my earliest attempt to make absolute electrostatic measurements, I used very small distances. I found great difficulty in securing that the distance should be nearly enough equal between different parts of the plates, and in measuring its absolute amount with sufficient accuracy; and found besides serious inconveniences in respect of sensibility and electric range: later I made a great improvement in the instrument by making only a small central area of one of the disks moveable. Thus the electric part of the instrument becomes two large parallel plates with a circular aperture in one of them, nearly filled up by a light circular disk supported properly to admit of its electrical attraction towards the other being accurately measured in absolute units of force. The disk and the perforated plate surrounding it will be called, for brevity, the disk and the guard-plate. The faces of these two next the other plate must be as nearly as possible in one plane when the disk is precisely in the position for measuring its electric force, which, for brevity, will be called its sighted position. The space between the disk and the inner edge of its guard-ring must be a very small part of the diameter of the aperture, and must be very small in comparison with the distance between the plates; but the diameter of the disk may be greater than, equal to, or less than the distance between the plates.

§ 20. Mathematical theory shows that the electric attraction experienced by the disk is the same as that experienced by a certain part of one of two infinite planes at the same distance, with the same difference of electric potentials, this area being very approximately the mean between the area of the aperture and the area of the disk, and that the approximation is very good, even although the distance between the plates be as much as a fourth or fifth, and the diameter of the disk as much as three-fourths of the diameter of the smaller of the two plates. This conclusion will be readily assented to when we consider that† the resultant electric force at any point in the air between the two plates is equal numerically to the rate of conduction of heat per unit area across the corresponding space in the following thermal analogue. Let a solid of uniform thermal conductivity replace all the air between and round the plates; and in place of the plates let there be hollow spaces in this solid. Let these hollow spaces be kept at two uniform temperatures, differing by a number of degrees equal numerically to the difference of potentials in the electric system, the space corresponding to the disk and guard-ring being at one temperature, and that corresponding to the opposite plate at the other temperature; and let the thermal conductivity of the solid be unity. If we attempt to draw the isothermal surfaces between

* Phil. Mag. September and October 1860.

† "On the Uniform Conduction of Heat through Solid Bodies, and its connexion with the Mathematical Theory of Electricity," Cambridge Mathematical Journal, Feb. 1842, and Phil. Mag. July 1854.

the hollow corresponding to the continuous plate on the one side, and that corresponding to the disk and guard-ring on the other side, we see immediately that they must be very nearly plane, from very near the disk all the way across to the corresponding central portion of the opposite plate, but that there will be a convexity towards the annular space between the disk and guard-ring.

§ 21. Thus we see that the resultant electric force will, to a very close approximation, be equal to $\frac{V}{D}$ for all points of the air between the plates at distances from the outer bounding edges exceeding two or three times the distance between the plates, and at distances from the interstice between the guard-ring and disk any less than the breadth of this interstice. Hence if ρ denote the electric density of any point of the plate or disk far enough from the edges, we have

$$\rho=\frac{V}{4\pi D}.$$

But the outward force experienced by the surface of the electrified conductor per unit of area at any point is $2\pi\rho^2$, and therefore if F denote the force experienced by any area A of the fixed plate, any part of which comes near its edge, we have

$$F=\frac{V^2A}{8\pi D^2},$$

which will clearly be equal to the attraction experienced by the moveable disk, if A be the mean area defined above. This gives $V=D\sqrt{\frac{8\pi F}{A}}$, the formula by which difference of potentials in absolute electrostatic measure is calculated from the result of a measurement of the force F, which, it must be remembered, is to be expressed in kinetic units. Thus if W be the mass in grammes to which the weight is equal, we have

$$F=gW,$$

where g is the force of gravity in centimetres per second.

The difficulty which, in first applying this method about twelve years ago, I found in measuring accurately the distance D between the plates and in avoiding error from their not being rigorously parallel, I now elude by measuring only *differences* of distance, and deducing the desired results from the difference of the corresponding differences of potentials. Thus let V′ be the difference of potentials between the plates required to give the same force F; when the difference of potentials is V′ instead of V, we have

$$V'-V=(D'-D)\sqrt{\frac{8\pi F}{A}}.$$

§ 22. The plan of proceeding which I now use is as follows:—Each plate (fig. 11, Plate VI.) is insulated; one of them, the continuous one, for instance, is kept at a potential differing from the earth by a fixed amount tested by aid of a separate idiostatic* electrometer; the other plate (the guard-ring and moveable disk in metallic communication with one another) is alternately connected with the earth and with the body whose potential is to be measured. The lower plate is moved up or down by a micrometer-screw until the moveable disk balances in a definite position, indicated by the hair (with background of white with black dots) seen through a lens, as shown in fig. 11. Before and after commencing each series of electrical experiments,

* See § 40 below.

the amount of weight to be placed on the upper side of the disk to bring the hair to its sighted position when there is no electric force is determined. This last condition is secured by putting the two plates in metallic communication with one another. For the electric experiments the weight is removed, so that when the hair is in the sighted position the electric attraction on the moveable disk is equal to the force of gravity on the weight. The electric connexions suitable in using this instrument for determining in absolute electrostatic measure the difference of potentials maintained by a galvanic battery between its two electrodes are indicated in fig. 11. No details as to the case for preventing disturbance by currents of air, and for maintaining a dry atmosphere, by aid of pumice impregnated with strong sulphuric acid, are shown, because they are by no means convenient in the instrument at present in use, which has undergone so many transformations that scarcely any part of the original structure remains. I hope soon to construct a compact instrument convenient for general use. The amount of force which is constant in each series of experiments may be varied from one series to another by changing the position of a small wire rider on the lever from which the moveable disk is hung.

The electric system here described is heterostatic (§ 40 below), there being an independent electrification besides that whose difference of potential is to be measured.

Portable Electrometer.

§ 23. In the ordinary use of the portable electrometer (figs. 8, 9, & 10, Plate VI.), the electric system is heterostatic and quite similar to that of the absolute electrometer, when used in the manner described above in § 22. But the balance is not adapted for absolute measure of the amount of force of attraction experienced by the moveable disk; on the contrary, it is precisely the same as that described for the gauge of the quadrant electrometer in § 13 above, only turned upside down. Thus, in the portable instrument, the square disk (f) forming part of the lever of thin sheet aluminium is attracted *upwards* by a solid circular disk of sheet-brass (g), thick enough for stiffness. Every part of the aluminium lever except this square portion is protected from electric attraction by a fixed brass plate ($h\,h$) with a square hole in it, as nearly as may be stopped by the square part of the sheet aluminium destined to experience the electric attraction, all other parts of the aluminium balance-lever being below this guard-plate. The aluminium lever ($i\,k$), as shown in figs. 8 & 10, is shaped so that when the hair (l) at the long end of its lever is in its sighted position, the upper surfaces of the fixed guard-plate (h) and moveable aluminium square (f) are as nearly as may be in one plane. The mode of suspension is precisely the same as that described (§ 13) for the gauge of the quadrant electrometer. In the portable instrument, careful attention is given by the maker to balance the aluminium lever by adding to it small masses of shellac or other convenient substance, so that its centre of gravity may be in the line of its platinum-wire axis, or, more properly speaking, in such a position that the instrument shall give, when electrified, the same "earth-readings" when held in any positions, either upright, or inclined, or inverted (§ 30 below). Thus the condition of equilibrium of the balance, when the hair is in its sighted position, is that the moment of electric attraction round the axis of suspension shall be equal to the moment of the couple of torsion, the latter being as constant as the properties of the matter concerned (platinum wire, brass stretching-springs, &c.) will allow.

§ 24. The guard-plate carrying, by the platinum-wire suspension, the aluminium balance, is attached to the bottom of a small glass Leyden jar (*m m*), and is in permanent metallic communication with its inside coating of tinfoil. The outside tinfoil-coating of this jar is in permanent metallic communication with the outside brass-protecting case. The upper open mouth of this case is closed by a lid or roof, which bears on its underside a firm frame projecting downwards. This frame has two V notches, in which a stout brass tube (*o*) slides, kept in the Vs by a properly placed spring (*p*), giving it freedom to slide up and down in one definite line*. Firmly fixed in the upper end of this tube is a nut (*a*, fig. 8), which is caused to move up and down by a micrometer-screw. The lower end of the shaft of this screw has attached to it a convex piece of polished steel (*b*, fig. 8), which is pressed upon a horizontal agate-plate rigidly attached to the framework above mentioned by a stiff brass piece projecting into the interior of the brass tube through a slot long enough to allow the requisite range of motion. This arrangement will be readily understood from the accompanying drawings. It has been designed upon obvious geometrical principles, which have been hitherto neglected, so far as I know, in all micrometer-screw mechanisms, whether for astronomical instruments or other purposes. The screw-shaft is turned by a milled head, fixed to it at its top outside the roof of the instrument, and the angles through which it is turned are read on a circle divided into 100 equal parts of the circumference (or $3^{\circ}\cdot6$ each) from a fixed mark on the roof of the instrument. The hole in the roof through which the screw-shaft passes is wide enough to allow the shaft to turn without touching it, and the lower edge of the graduated circle turning with the screw is everywhere very near the upper side of the roof, but must not touch it at any point. A second nut (*c*, fig. 8) above the effective nut fits easily, but somewhat accurately, in the hollow brass tube, but is prevented from turning round in the tube by a proper projection and slot. Thus the screw is rendered sufficiently steady, with reference to the sliding-tube; that is to say, it is prevented from any but excessively small rotations round axis perpendicular to the length of the screw-shaft; and when the nut is kept from being turned round its proper axis, it forms along with the sliding-tube virtually a rigid body. A carefully arranged spiral spring presses the two nuts asunder, and so causes the uppersides of the thread of the screw-shaft always to press against the underside of the thread of the effective nut, thus doing away with what is technically called in mechanics "lost time." In turning the micrometer-screw, the operator presses its head gently downwards with his finger, to secure that its lower end bears firmly upon the agate-plate. It would be the reverse of an improvememt to introduce a spring attached to the roof of the instrument outside to press the screw head downwards, inasmuch as however smooth the top of the screw-shaft might be made, and however smooth the spring pressing it down, there would still be a very injurious friction impeding the proper settlement of the sliding-tube into its Vs. A stiff fork (*q*) stretching over the graduated circle is firmly attached to the roof outside, to prevent the screw from being lifted up by more than a very small space; perhaps not more than $\frac{1}{20}$ of an inch at most. In using the instrument, the observer should occasionally pull up the screw-head and press it down again, and give it small horizontal motions, to make

* In consequence of suggestions by Mr. Jenkin, it is probable that the spring may be done away with, and the Vs replaced by rings approximately fitting round the tube, but leaving it quite free to fall down by its own weight. In consequence of the symmetrical position of the convex end of the screw over the centre of the attracted disk, slight lateral motions of the tube produce no sensible effect on the electric attraction.

sure that when he is using it it is pressed in properly to its Vs and down upon the agate-plate. A long arm (*d*, figs. 8 and 9) (or two arms one above the other), firmly attached to the sliding-tube, carries a pointer which moves up and down with it. Two fixed guiding-cheeks on each side of this pointer prevent the tube from being carried round too far in either direction when the screw is turned: one of these cheeks is graduated so that each division is equal in length to the step of the micrometer-screw; this enables the operator to ascertain the number of times he has turned the screw. These two cheeks must never simultaneously press upon the sliding-pointer; on the contrary, they must leave it a slight amount of lateral freedom to move. If this does not amount to ·36 of a degree, the amount of "lost time" produced by it will not exceed $\frac{1}{10}$ of a division of the micrometer-circle, and will not produce any sensible error in the use of the instrument. A glass rod cemented to the lower end of the tube prolongs its axis downwards, and bears the continuous attracting-plate of the electrometer at its lower end.

The object aimed at in the mechanism just described is to prevent the nut and other parts rigidly connected with it from any other motion than parallel to one definite line, and to leave it freedom to move in this line, unimpeded by any other friction than that which is indispensable in the arrangement for keeping the sliding tube in its Vs.

§ 25. If the inner tinfoil covering of the Leyden jar were completed up to the guard-plate bearing the aluminium balance, the long arm of this lever being in the interior of a hollow conductor would experience no electric influence, and no force from the electrification of the Leyden jar, or from separate electrification of the upper attracting-plate, or, more strictly speaking, the electric density and consequent electric force on the long arm of the lever would be absolutely insensible to the most refined test we could apply, because of the smallness of the gap between the moveable aluminium square and the boundary of the square aperture in the guard-plate. But to see the hair on the long end of the lever, and the white background with black dots behind it, a good portion of the glass under the guard-plate must be cleared of tinfoil outside and inside. Thus the electric potential of the inner coating of the Leyden jar will not be continued quite uniformly over the inner surface of the bared portion of the glass, and a disturbance affecting chiefly the most sensitive part of the lever will be introduced. To diminish this as much as possible without inconveniently impeding vision, a double screen of thin wire fences, in metallic communication with the inner tinfoil coating and the guard-plate, is introduced between the end of the lever and the glass through which it is observed.

§ 26. A very light spiral spring (*r*) connects the upper attracting-plate with a brass piece supported upon a fixed vertical glass column projecting downwards from the roof of the instrument. This brass piece bears a stout wire (*s*), called the main electrode, projecting vertically upwards along the axis of a brass tube open at each end, fixed in an aperture in the roof so as to project upwards and downwards, as shown in fig. 9.

§ 27. The top of the main electrode bears a brass sliding-piece (*t*), which, when raised a little, serves for umbrella and wind-guard without disturbing the insulation; and when pressed down closes the aperture and puts the electrode in metallic connexion with the roof of the instrument. When the instrument is to be used for atmospheric electricity (unless at a fixed station), a steel wire, about 20 centimetres long, is placed in the hole on the top of the sliding brass piece just mentioned, and is thus held in the vertical position. A burning match is attached to its upper end, which has the effect of

bringing the potential of the chief electrode and upper attracting-plate &c. all to the potential of the air at the point where the match burns*. The instrument is either held in the observer's hand, or it is placed upon a fixed support, and care taken that its outer brass case is in connexion with the earth. When the difference of potentials between two conductors is to be tested, one of these is connected with the brass case of the instrument, and the other with the chief electrode, the umbrella being kept up. If both of these conductors must be kept insulated from the earth, the brass case of the electrometer must be put on an insulating stand, and the micrometer-screw turned by an insulating handle.

§ 28. A lead cup (*e e*, fig. 8), supported by metal pillars from the roof and carrying pieces of pumice-stone, held in their place by India-rubber bands, completes the instrument. The inner surface of the glass must be clean, and particles of dust, minute shreds or fibres, &c. removed as carefully as possible, especially from the lower surface of the upper attracting-plate, and the upper surface of the guard-plate and aluminium square facing it from below. The pumice is prepared by moistening it with a few drops of strong pure sulphuric acid. Ordinary sulphuric acid of commerce should be boiled with sulphate of ammonia to free it from volatile acid vapours, and to strengthen it sufficiently by removing water if the acid be not of the strongest. There should not be so much acid applied to the pumice as to make it have the appearance of being moist, but there must be enough to maintain a sufficiently dry atmosphere within the instrument for very perfect insulation of the Leyden jar, which I find does not in general lose more of its charge than 5 per cent. per week, when the pumice is properly acidulated. Thus there is no tendency of the liquid to drop out of the pumice; and the pumice being properly secured by the india-rubber bands, the instrument may be thrown about with any force, short of that which might break the glass jar or either of the glass stems, without doing any damage; but to ensure this hardiness the sheet aluminium of which the balance is made must be *very thin*. After several weeks' use the pumice may commence to look moist, and even slight traces of moisture may be seen on the outside of the lead cup, in consequence of watery vapour attracted by the sulphuric acid from the atmosphere; but the pumice should then be taken and dried. At all events this must be done in good time, before enough of liquid has collected to give any tendency to drop. In all climates in which I have hitherto tested the instrument, I have found the pumice effective for insulation and safe in keeping all the liquid to itself for two months. But it having been reported to me by Mr. Becker that many instruments have been returned to him in a ruinous condition from drops of sulphuric acid having become scattered through their metal work, I now cause to be engraved conspicuously on the outer case of the instrument "PUMICE DANGEROUS, IF NOT DRIED ONCE A MONTH;" also a frame carrying a card, on which the dates of drying are inscribed, to be placed in a convenient position on the roof of the instrument.

§ 29. To prepare the instrument for use, the inner coating of the Leyden jar must be charged through a charging rod, insulated in a vulcanite or glass tube, and let down for the occasion through a hole in the roof of the instrument, by aid of a small electrophorus, which generally accompanies the instrument, or by an electrical machine. I generally prefer to give a negative charge to the inner coating, as I have not found any physical reason, such as that mentioned in § 9 above, to prefer a positive charge

* See Nichol's Cyclopædia, article "Electricity, Atmospheric," 2nd edition, 1860; or "Royal Institution Lecture on Atmospheric Electricity," May 1860.

to a negative charge; and the negative charge gives increased readings of the micrometer, in the ordinary use of the instrument, to correspond to positive charges of the principal electrode, as will be presently explained. Before commencing to charge the jar, the upper attracting-plate should be moved to nearly the highest position of its range by the micrometer-screw, otherwise too strong a force of electric attraction may be put upon the aluminium square; and besides, the jar will discharge itself between the upper plate and the extreme edge of the aluminium square, pulled as it is very much above the level of the guard-plate by the electric attraction. I have not found any injury or change of electric value of the scale-divisions to arise from any such rough usage; but still, to guard against such a possibility, I propose to add to the guard-plate checks to prevent the corners of the aluminium from rising much, if at all, above its level, and to conduct the discharge and protect the aluminium and platinum from the shock, in case of the upper plate being brought too near the lower. When the instrument is being charged, or when it is out of use at any time, the umbrella should always be kept down; but it must be raised to insulate the principal electrode, of course, before proceeding to apply this to a body whose difference of potential from a body connected with the case of the instrument is to be measured.

§ 30. In using the instrument the umbrella must very frequently be lowered, or metallic communication established in any other convenient way between the chief electrode and the outer brass case, the micrometer-screw turned until the hair takes its sighted position, and the reading taken, the hundreds being read on the interior vertical scale, and the units (or single divisions of the circle) on the graduated circle above. The number thus found is called the earth-reading. It measures the distance from an arbitrary zero position to the position in which the upper attracting-plate must be placed to give the amount of electric force on the aluminium square which balances the lever in its sighted position. A constant added to the earth-reading, or subtracted from it, gives (§ 1) a number simply proportional to the difference of potentials between the upper and lower plate; that is to say, between the two coatings of the Leyden jar. The vertical scale and micrometer-circle are numbered, so that increased distances between the plates gives increased readings; and the zero reading should correspond as nearly as may be to zero distance between them; although in the instruments hitherto made no pains have been taken to secure this condition, even somewhat approximately. If it is desired to know the constant, an electrical experiment must be made to determine it, which is done with ease; but this is not necessary for the ordinary use of the instrument, which is as follows.

§ 31. First, an earth-reading is taken, then the upper electrode is insulated by raising the umbrella, or otherwise breaking connexion between the principal electrode and the outer metal case of the instrument. The principal electrode and the outer case are then connected with the two bodies whose difference of potential is to be determined, and the micrometer-screw is turned until the hair is brought to its sighted position. The reading of hundreds on the vertical scale and units on the circle is then taken. Lastly, the principal electrode is again connected with the case of the instrument and another earth-reading is taken. If the second earth-reading differs from the first, the observer must estimate the most probable earth-reading for the moment when the hair was in its sighted position, with the upper plate and the metal case in connexion with the two bodies whose difference of potential is to be measured. The estimated earth-reading is to be sub-

tracted from the reading taken in connexion with the bodies to be tested. This difference measures (§ 21) the required difference of potentials between them in units of the instrument. The value of the unit of the instrument ought to be known in absolute electrostatic measure; and the difference of reading found in any experiment is to be multiplied by this, which is called (§ 1) the absolute coefficient of the instrument, to give the required difference of potentials in absolute measure. It so happens that, in the portable electrometers of the kind now described which have been hitherto constructed, the absolute coefficient is somewhere about ·01, so that one turn of the screw, or 100 divisions of the circle, corresponds to somewhere about one electrostatic unit, with a gramme for the unit of mass, a centimetre for the unit of distance, and a second for the unit of time; but the different instruments differ from one another by as much as ten or twenty per cent. in their absolute coefficients. In all of these I have found between three and four Daniell's cells to correspond to the unit division; that is to say, between three hundred and four hundred cells to a full turn of the screw. With great care, the observer may measure small differences of potentials by this instrument to the tenth part of a division (or to about half a Daniell's cell). With a very moderate amount of practice and care, an error of as much as a half division may be avoided in each reading.

§ 32. But there are imperfections in the instrument itself which make it difficult or impossible to secure very minute accuracy, especially in measurements through wide ranges.

(1) In the first place, I am not sure that the end of the needle carrying the hair is protected sufficiently by the wire fences (§ 25) from electric disturbance to provide against any error from this source, which possibly introduces serious irregularities.

(2) In the second place, the capacity of the jar in the small portable instrument is not sufficient to secure that the potential of its inner coating shall not differ sensibly with the different distances to which the upper plate is brought, to balance the aluminium lever with the hair in its sighted position. But on this point it is to be remarked that the electric density on the upper surface of the guard-plate is in its central parts always the same when the hair is in its sighted position; and it is therefore only the comparatively small difference of the quantity of electricity on this surface, towards the rim, corresponding to different distances of the attracted plate, that causes difference of potential in the inner coating of the jar. But if the upper attracting-plate be kept for several minutes at any distance, differing by a few turns of the screw, from that which brings the hair to its sighted position, the electricity creeps along the inner unconnected surface of the glass so as to increase the charge of the inner metallic coating, or diminish it, according as the distance is too great or too small. If then quickly the screw be turned and the earth-reading taken, it is found greater or smaller, as the case may be, than previously; but after a few minutes more it returns to its previous value very approximately. Error from this source may be practically avoided by taking care never to allow the hair to remain for more than a few minutes far from its sighted position; never so far, for instance, as above the centre of the upper, or below the centre of the lower dots.

(3) A third source of error arises from change of temperature influencing the indications. In most of the instruments hitherto made I have found that the warmth of the hand produces in a few minutes a very notable augmentation of the earth-reading (as it were an increased charge in the jar); but in the last instrument which I have tested (White No. 18) I find the

reverse effect, the earth-reading becoming smaller as the instrument is warmed, or larger when it is cooled. I have ascertained that these changes are not due to changes in the electric capacities of the Leyden jars; and I have found that the change, if any, of specific inductive capacity of glass by change of temperature is excessively small, in comparison to what would be required to account for the temperature errors of these instruments, which probably must be due to thermo-elastic properties of the platinum wire, or of the stretching-springs, or of the aluminium balance-lever, or to a combination of the effects depending on such properties; but I have endeavoured in vain, for several years, and made many experiments, to discover the precise cause. It surely will be found, and means invented for remedying the error, now when I have an instrument in which the error is in the opposite direction to that of most of the other instruments. It is of course much greater in some instruments than in others: in some it is so great that the earth-reading is varied by as much as twenty divisions by the warmth of the hand in the course of five or ten minutes after commencing to use the instrument, if it has been previously for some time in a cold place. Its influence may be eliminated, not quite rigorously, but nearly enough so for most practical purposes, by frequently taking earth-readings (§ 30) and proceeding according to the directions of § 31.

(4) A fourth fault in the portable electrometer is, that the diameter of the guard-plate and upper attracting disk, which ought to be infinite, are not sufficiently great, in proportion to the greatest distance between them, to render the scale quite uniform in its electric value throughout. A careful observer will, however, remedy the greater part of the error due to this defect, by measuring experimentally the relative (or absolute) values of the scale-division in different parts of the range. There will, however, remain uncorrected some irregularity, due to influence of the distribution of electricity over the uncoated inner surface, in the instruments as hitherto made, in all of which the inner surface of the jar is coated with tinfoil only below the guard-plate, so that the upper surface of the guard-plate may be seen clearly, in order that the observer may always see that all is in order about the aluminium square and aperture round it; and particularly that there are no injurious shreds or minute fibres. But the irregular influence of the electrification of the uncoated glass, if found sensible, will be rendered insensible by continuing the tinfoil coating an inch above the upper surface of the guard-plate.

§ 33. All faults, except the temperature error, depend on the smallness of the instrument; and if the observer chooses to regard as portable an instrument of thirty centimetres (or a foot) diameter, with all other dimensions, and all details of construction, the same as those of the instrument described above, he may have a portable electrometer practically free from three of the four faults described. But it is scarcely to be expected that a small instrument ($12\frac{1}{2}$ centimetres high, and $8\frac{1}{2}$ centimetres in diameter) which may be carried about in the pocket can be free from such errors. They are, however, so far remedied as to be probably not perceptible in the large stationary instrument which I now proceed to describe.

Standard Electrometer.

§ 34. This instrument (figs. 12, 13, & 14, Plate VI.) differs from the portable electrometer only in dimensions, and in certain mechanical details, which are arranged to give greater accuracy by taking advantage of freedom from the exigencies of a small portable instrument. It is at present called the standard

electrometer, in anticipation of either remedying, or of learning to perfectly allow for, the temperature error, and of finding by secular experiments on the elasticity of metals, that their properties used in the instrument are satisfactory as regards the permanence from year to year, and from century to century, of the electric value of its reading. It is an instrument capable of being applied with great ease to very accurate measurements of differences of potential, in terms of its own unit. The value of the unit for each such standard instrument ought, of course, to be determined with the greatest possible accuracy in absolute measure; and until confidence can be felt as to its secular constancy, determinations should frequently be made by aid of the absolute electrometer.

§ 35. The Leyden jar of the standard electrometer consists of a large thin white-glass shade coated inside and outside to within 6 centimetres of its lip, and placed over the instrument as an ordinary glass shade, to protect against dust, currents of air, and change of atmosphere. It may be removed at pleasure from the cast-iron sole of the instrument, and then the interior works are seen, consisting of

(1) A continuous disk of brass supported on a glass stem, in prolongation of a stout brass rod or tube sliding vertically in Vs, in which it is kept by a spring, and resting with its lower flat end on the upper end of a micrometer-screw shaft, shown in fig. 13, where the screw, graduated circle, and stout brass rod are as seen in the instrument; the perforated brass disk (which is intended to keep the round upper end of the screw-shaft in position) is shown in section in fig. 14.

(2) Resting on three glass columns, a guard-plate with a square aperture in its centre, and carrying on its upper side stretching-springs and thin platinum-wire suspension of an aluminium balance-lever, shaped like those of the gauge (§ 13) and the portable (§ 23) already described, but somewhat larger. The tops of the three glass columns are rounded; a round hole and a short slot in line with this hole are cut in the guard-plate and receive the rounded ends of two of the columns, which are somewhat longer than the third. The flat smooth lower surface of the guard-plate rests simply on the top of the third glass column. The diameter of the round hole and the breadth of the slot in the guard-plate may be about $\frac{1}{\sqrt{2}}$ of the diameter of curvature of the upper hemispherical rounded ends of the glass column, so that the bearing portions of the rounded ends in the round hole and in the slot respectively may be inclined somewhere about 45° to the plane of the plate. This well-known but too often neglected geometrical arrangement gives perfect steadiness to the supported plate, without putting any transverse strain upon the supporting glass columns, such as was almost inevitable, and caused the breakage of many glass stems, before mental inertia opposing deviations from the ordinary instrument-maker's plan (of screwing the guard-plate to brass mountings cemented to the tops of the glass columns) was overcome. It has also the advantage of allowing the guard-plate to be lifted off and replaced in a moment.

(3) Principal electrode projecting downwards through a hole in the sole of the instrument, and rigidly supported from above by a brass mounting cemented to the top of a thick vertical glass column, connected by a light spiral spring with the lower attracting-plate moved up and down by the micrometer-screw. The aperture round the principal electrode may be ordinarily stopped by a perforated column of well-paraffined vulcanite projecting some distance above and below the aperture, which I find to insulate

extremely well, even in the smoky, dusty, and acidulated atmosphere of Glasgow. When an extremely perfect insulation of the principal electrode and connected attracting-plate is required, the vulcanite stopper surrounding it may be removed, so that the only communication between the electrode and the case of the instrument may be along the two glass columns in the artificially dried interior atmosphere of the case; but from day to day, when the instrument is out of use, the aperture round the principal electrode should be kept carefully stopped, if not by a vulcanite insulator by a perforated cork (although I find but little loss of insulation, either by the inner glass surface of the Leyden jar or by the three glass columns, when this precaution is neglected).

(4) Temporary charging-rod supported by a vertical perforated column of paraffined vulcanite, or a glass tube well varnished outside and thickly paraffined inside. The insulating column bearing this charging-rod is turned round till a horizontal spring projecting from its upper end touches the inner coating of the jar, when this is to be charged from an independent source, or when, for any other experimental reason, it is to be put in connexion with a conductor outside the case of the instrument.

(5) A small replenisher of the kind described for the quadrant electrometer (§ 12), but with much wider air-spaces to prevent discharge by sparks.

(6) A large glass or lead dish to hold as large masses of pumice as may be, which are to be kept sufficiently impregnated with strong sulphuric acid.

§ 36. A considerable position of the jar above the guard-plate is left uncoated to allow the observer to see easily the hair and white background with black dots; also several other smaller parts of the glass above the guard-plate are left uncoated to admit light to allow a small circular level on the upper side of the guard-plate to be seen. The long arm of the aluminium balance-lever is very thoroughly guarded by double cages and fences of wire (§ 25), so that it can experience no sensible influence from electric disturbing forces when the covering jar is put in position and electric connexion is established between its inner coating and the guard-plate by projecting flexible wires or slips of metal.

§ 37. The aluminium square plate is somewhat larger, and the platinum bearing wire somewhat longer in this instrument than in the portable electrometer, to render it sensible to smaller differences of potential. The step of the screw is the same as in the portable ($\frac{1}{50}$ of an inch), and one division ($\frac{1}{100}$ of the circumference of the screw-head) corresponds to a difference of potentials which, roughly speaking, is equal to about that of a single cell of Daniell's. The effective range of the instrument is about sixty turns of the screw, and therefore about 6000 cells of Daniell's. That of the portable electrometer is about 15 turns of the screw (equivalent to about 5000 cells). Neither of these instruments has sufficient range to measure the potential to which Leyden jars are charged in ordinary electric experiments, or those reached by the prime conductor of a powerful electric machine. The stationary instrument with its long screw and its large plates now described, would go far towards meeting this want if its aluminium lever and platinum suspension were made on the same scale as those of the portable electrometer; but for an instrument never wanted to directly measure differences of potentials of less than two or three thousand cells, the heterostatic (§ 40) principle is in general not useful, and therefore I have constructed the following very simple idiostatic (§ 40) instrument, which is adapted to measure with considerable accuracy differences of potential from 4000 cells upwards, to about 80,000 cells.

Long-range Electrometer.

§ 38. In this (fig. 15, Plate VI.) the continuous attracting-plate is above, and the guard-plate with aluminium balance below, as in the portable electrometer; but, as in the standard stationary electrometer, the upper plate is fixed and the lower plate is moved up and down by a micrometer-screw. The mechanism of the screw and slide has all the simplicity and consequent accuracy of that of the standard electrometer. In the only long-range instrument yet constructed the step of the screw is the same as that of the others ($\frac{1}{50}$ of an inch). In future instruments it would be well either to have a longer step or to have a simple mechanism (which can be easily added) to give a quick motion; as in the use of the present instrument, the turning of the screw required for great changes of the potential measured is very tedious. The guard-plate projects by more than an inch all round beyond the rim of the upper attracting-plate; partly to obviate the necessity of giving it a thick rim, which would be required to prevent brushes and sparks originating in it, if it had only the same diameter as the continuous plate above, and partly to guard the observer from receiving a spark or shock in measuring the potential of an electric machine or of a Leyden battery, and to prevent the hair from being attracted to the upper plate. Thus the guard-plate is allowed to be no thicker than suffices for stiffness, and this allows the observer to see the hair at the end of the aluminium balance-lever without the lever being made of a dynamically disadvantageous shape, as would be necessary if the guard-plate were thick or had a thick rim added to it. No glass case is required for this instrument. The smallness of the needle and the greatness of the electric force acting on it are such that I find in practice no disturbance to any inconvenient degree by ordinary currents of air; although it and all these attracted disk instruments show the influence of sudden change of barometric pressure, such as that produced by opening or shutting a door. If not kept under a glass shade when out of use, the lower surface of the upper attracting-plate and the lower surface of the guard-plate and attracted aluminium square should be carefully dusted by a dry cool hand. Generally speaking, none of the vital electric organs of an electrometer should be touched by a cloth, as this is almost sure to leave shreds fatal to their healthy action.

§ 39. The effective range of this instrument is about 200 turns of the screw; rather greater force of torsion is given than in the portable electrometer, and a rather smaller attracted disk may be used, so that upwards of four cells may be the electric value of one division. The instrument in its present state measures nearly but not quite the highest potential I can ordinarily produce in the conductor of a good Winter's electric machine, which sometimes gives sparks and brushes a foot long.

§ 40. The classification of electrometers given above is founded on the shape and kinematic relations of their chief organic parts; but it will be remarked that another principle of classification is presented by the different electric systems used in them, which may be divided into two classes:—

I. Idiostatic, that in which the whole electric force depends on the electrification which is itself the subject of the test.

II. Heterostatic, in which, besides the electrification to be tested, another electrification maintained independently of it is taken advantage of.

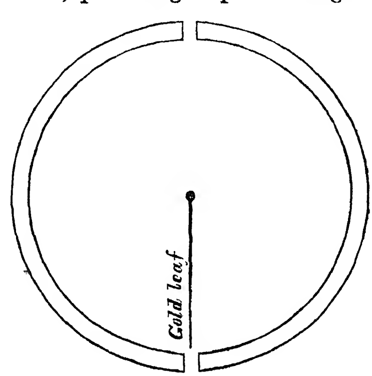
Thus, for example, the long-range electrometer (§§ 38, 39) is simply idiostatic and is not adapted for heterostatic use; but each of them may be used idiostatically. The absolute electrometer was at first simply idiostatic

(§§ 17–21); more recently it has been used heterostatically, and is about to acquire (§ 22) special organs adapted for heterostatic use; as yet, however, no species of the absolute electrometer promising permanence has come into existence.

§ 41. It is instructive to trace the origin of various heterostatic species of electrometers by natural selection. A body hanging, or otherwise symmetrically balanced, in the middle of a symmetrical field of force, but free to move in one direction or the other in a line tangential to a line of force, moves in one direction or the opposite when electrified positively or negatively. Bohnenberger's arrangement of this kind has a convenient and approximately constant field of force; and his instrument was chosen in preference to others which may have been equally sensitive, but were less convenient and constant, and it became a permanent species.

§ 42. Bennet's gold-leaf electroscope, constructed with care to secure good insulation, electrified sufficiently to produce a moderate divergence, has been often used to test, by aid of this electrification, the quality of the electrification of an electrified body brought into the neighbourhood of its upper projecting electrode, causing, if its electricity is of the same sign as that of the gold leaves, increase of divergence; if of the opposite sign, diminution. By connecting the upper electrode with the inner coating of a Leyden jar with internal artificially dried atmosphere, the charge of the gold leaves may be made to last with little loss from day to day; and by insulating Faraday's metal cage (§ 2) round the gold leaves and alternately connecting it with the earth and with a conductor whose difference of potentials from the earth is to be tested, an increase or a diminution of divergence is observed according as this difference is negative or positive, the gold leaves being positive. Hence (through Peltier's and Delmann's forms) the heterostatic stationary and portable repulsion electrometers, described in the Royal Institution Lecture on "Atmospheric Electricity" and in Nichol's Cyclopædia, article "Electricity, Atmospheric," already referred to, of which one species still survives in King's College, Nova Scotia, and in the Natural Philosophy Class Room of Edinburgh University. The same form of the heterostatic principle applied to Snow Harris's attracted disk electrometer gave the portable and standard electrometers described above.

§ 43. A modification of Bohnenberger's electroscope, in which the two knobs on the two sides of the hanging gold leaf became transformed into halves of a circular cylinder, with its axis horizontal and the gold leaf hung on a wire insulated in a position coinciding with its axis, producing a species designed for telegraphic purposes, but which did not acquire permanence by natural selection, and is only known to exist in one fossil specimen. In this instrument the wire bearing the gold leaf was connected with a charged Leyden jar, and the semicylinders with the bodies whose difference of potential was to be tested. But various modifications of the divided-cylinder or divided-ring class with the axis vertical and plane of motion horizontal have done some practical work, and one species, the new quadrant electrometer (§ 6), promises to become permanent.



§ 44. The heterostatic principle in one form or other is essential to distinguish between positive and negative. As remarked above (§ 42), the original type of this use of it is to be found in the old system of testing the quality of the charge taken by the diverging straws or gold leaves of the electroscopes used for the observation of atmospheric electricity; which was done by bringing a piece of rubbed sealing-wax into the neighbourhood, and observing whether this caused increase or diminution of the divergence. A doubt which still exists as to the sign* of the atmospheric electricity observed by Professor Piazzi Smyth on the Peak of Teneriffe, is owing to the imperfection of this way of applying the principle. It is, indeed, to be doubted in any one instance whether it is not vitreous electricity that the rubbed sealing-wax acquires. And, again (§ 2), it is not certain that the glass case enclosing the gold leaves, especially if very clean and surrounded by a very dry natural atmosphere, screens them sufficiently from direct influence of the piece of sealing-wax to make sure that the divergence due to vitreous electricity could not be increased by the presence of the resinously electrified sealing-wax if held nearer the gold leaves than the upper projecting stem.

§ 45. The heterostatic principle has a very great advantage as regards sensibility over any simple idiostatic arrangement, inasmuch as, for infinitely small differences of potential to be measured, the force is as the squares of the differences in any idiostatic arrangement, but is simply proportional to the differences in every heterostatic arrangement.

VI. *Determination of the Dynamical Equivalent of Heat from the thermal effects of Electric Currents.* *By* J. P. Joule, *D.C.L., F.R.S., &c.*

Sir W. Thomson, as long ago as 1851, showed that it was desirable to make experiments such as are the subject of the present paper. They have necessarily been delayed until a sufficiently accurate method of measuring resistance was discovered. Such a method having been described by Sir William, and carried out into practice by Professor C. Maxwell and his able coadjutors, the task assigned to me by the Committee of Electric Standards was comparatively simple.

My experiments were commenced nearly two years ago, and the apparent ease with which they could be executed gave promise of their early completion. It was, however, found essential that careful observations of the earth's horizontal magnetic intensity should be frequently made, and these required the construction of apparatus whereby this element could be determined with accuracy and rapidity.

The apparatus finally adopted for this purpose consists of a suspended horizontal flat coil of wire between two fixed similar coils. A current of electricity can be made to traverse all three, communication with the suspended coil being made by the suspending wires themselves according to Sir W. Thomson's plan. The strength of a current is found by observing the sum of the forces of attraction and repulsion by which the suspended coil is urged. The strength of a current can in this manner be determined in absolute measure. For the area of each of the three equal coils being called a, the weight required to counterpoise the force with which the suspended one is urged w, the force of gravity g, and the length of wire in each of the coils l, the current $c=\frac{1}{2l}\sqrt{\frac{agw}{\pi}}$ (1 + correction), the correction being principally

* Nichol's Cyclopædia, article "Electricity, Atmospheric," edition 1860.

due to the distance between the fixed coils. In my instrument, in which this distance is 1 inch, the diameter of the coils being 12 inches, and their interior core 4 inches, this correction was proved by experiment to be ·1185.

There was, however, considerable difficulty in obtaining an exact measure of the distance between the fixed coils, and I therefore judged that the measure of the currents used in the experiments would be most accurately obtained by means of a tangent galvanometer, the above described current-meter being employed to determine the horizontal intensity.

This determination was effected as follows:—Many careful observations of the horizontal intensity by an improved method on Gauss and Weber's system were made alternatively with observations of the deflections of a tangent galvanometer and the weighings of the current-meter when the same currents traversed both instruments in succession. Then calling the horizontal intensity H, the angle of deflection θ, and the weighing w, there was obtained a constant $c=\frac{H\tan\theta}{\sqrt{w}}=\cdot 17676$. Hence with these instruments

$$H=\frac{\cdot 17676\sqrt{w}}{\tan\theta}.$$

The experiments for the determinations of horizontal intensity by the use of this formula could be effected in a few minutes, and did not require an alteration in the disposition of any part of the apparatus. It was satisfactory to find that, although the presence of masses of iron at only a few yards distance made the field in which I worked considerably more intense than that due to the latitude, and although I worked at different times of the day, the highest intensity, out of upwards of seventy observations distributed over a year, was 3·6853, and the lowest 3·6607, indicating a much greater degree of constancy than might have been expected.

The galvanometer above mentioned was that employed in the thermal experiments. It had a single circle of $\frac{1}{10}$-inch copper wire, the diameter of which, being measured in many places by a standard rule, gave a radius of ·62723 of a foot. The needle was half an inch long, and furnished with a glass pointer traversing a divided circle of 6 inches diameter. In the experiments the deflections were not far from 26° 34′, the angle at which the influence of the length of the needle within certain limits is inappreciable. It was easy by a magnifier, arranged so as to avoid parallax, to read to one minute. The torsion of the fibre gave only 3′·5 for an entire twist. The trifling correction thus required is applied to the recorded observations of deflection.

The calorimeter first used was a copper vessel upwards of a gallon in capacity, filled with distilled water. It had a conical lid, attached by screws, in which were two tubulures, one for the introduction of a copper stirrer, the other for the thermometer, around the immersed stem of which a wire of platinum silver, having a resistance nearly equal to that of the Association unit, was coiled.

The resistance of the wire was found by comparing it with the Association unit, sent me by the Committee, using Ohm's formula, $x=\frac{C_2}{C_1}\left(\frac{C_3-C_1}{C_3-C_2}\right)$, where C_3, C_2, and C_1 are the tangents of deflection with the battery and connexions only with these and the unit and with the coil respectively. This, though by no means so delicate a method as that of the Wheatstone balance improved by Thomson, was able to give a final result certainly accurate to the two-thousandth part. The results for the resistance of the coil in the first series of experiments are as follow. They were obtained before and after

those experiments. A large galvanic cell, consisting of cast iron and amalgamated zinc plunged in dilute sulphuric acid, was the source of electricity, which was measured by a galvanometer with a coil of nine turns, 17 inches in diameter.

C_3.	C_2.	C_1.	Temperature of unit.	Temperature of coil.	Resistance of coil in terms of unit.
tan 55° 6'·75	tan 28° 18'	tan 28° 1'·3	63°·7	62°·65	1·01901
tan 59 32·5	tan 32 39·6	tan 32 22	59·24	58·39	1·01825

The average resistance 1·01863 being reduced from the temperature 14°·5 Cent., at which the unit was adjusted, to 69°·9 Fahr., the average temperature of the calorimeter in the first series of experiments becomes 1·0191, which, multiplied by 32808990, gives 33435640 as the resistance in British absolute measure.

A delicate thermometer was placed at a few inches distance from the calorimeter, for the purpose of registering the temperature of the air. In the Tables its indications are reduced to the scale of the instrument plunged in the calorimeter. A string attached the handle of the stirrer to a stick, so that the water could be effectually stirred without communicating the heat of the hand. A wooden screen separated the observer from the apparatus.

In the experiments of the first series a battery of five large Daniell's cells, arranged in series, transmitted the current through the coil for 40' exactly determined by chronometer. During this time twenty-eight observations of deflection were obtained, seven at each end of the pointer directed N.E. and S.W., and seven when it was directed N.W. and S.E. by reversing the current in the galvanometer for the latter half of the time. The water was stirred twenty-eight times. Its temperature was taken at the beginning, middle, and end of an experiment. There were also fourteen observations of the temperature of the air.

Immediately after each experiment the horizontal intensity of magnetic force was obtained by observing the deflection of the galvanometer and the weighing of the current-meter produced by the same current.

Before and after each experiment, two others were made in precisely the same manner, but excepting the current, in order to discover the influence of radiation and the conducting-power of the atmosphere.

First Series of Thermal Experiments.

Date.	Deflection.	$\tan^2$. Deflection.	Temperature of air.	Temperature of water.	Rise of temperature.	Horizontal intensity.
1866.						
Aug. 22 ...	32° 46'·86	·414719	492·36	497·42	23·55	3·6763
„ 23 ...	34 0·29	·455133	494·77	493·27	25·65	3·6815
Sept. 8 ...	32 24·83	·403156	400·4	401·8	22·8	
„ 10 ...	31 50·22	·385542	441·11	433·85	22·214	3·6737
„ 11 ...	31 31·02	·376024	367·0	392·89	18·51	3·6758
„ 12 ...	31 14·42	·367944	344·33	344·45	21·9	3·6656
„ 13 ...	30 57·51	·359850	361·54	358·47	20·95	3·6671
„ 15 ...	30 24·86	·344607	346·7	330·01	21·98	3·6638
„ 15 ...	30 20·51	·342610	381·41	367·56	21·07	3·6711
„ 18 ...	30 34·34	·348982	342·64	324·32	22·29	3·6607
Average ...	....	·379857	397·226	394·406	22·0914	3·67073

First Series of Radiation Experiments.

Date.	Temperature of air.	Temperature of water.	Rise of temperature of water.
1866.			
Aug. 22	495·93	469·14	2·88
"	502·22	477·83	3·15
Aug. 23	476·37	458·96	3·08
"	490·81	499·22	−0·55
Sept. 8	393·5	382·75	2·0
"	395·82	414·15	−1·7
Sept. 10	444·31	419·4	2·9
"	437·15	396 96	4·83
Sept. 11	373·07	384·72	−0·63
"	367·14	391·76	−1·75
Sept. 12	334·0	332·42	0·44
"	365·34	360·2	1·6
Sept. 13	352·82	343·11	1·83
"	366·65	369·16	−0·08
Sept. 15	330·78	315·41	2·78
" .. .	381·47	347 14	3·72
"	378·93	350 67	3·34
" . .	381·05	379·51	0·22
Sept. 18	326·99	309·28	2·55
" . .	339·9	338·35	0·04
Average	373·058	364·686	1·3806

In applying the preceding Table for the purpose of correcting the results of the thermal experiments, it must be first observed that the external influences on the calorimeter are not zero when the temperature of the air-thermometer coincides with the indication of that immersed in the calorimeter. This might arise partly from the locality of the two instruments not being the same, but was, I found, principally owing to the different radiating and absorbing powers of the air-thermometer bulb and of the surface of the calorimeter. Taking, then, the number of instances in which the temperature of the air appeared to exceed that of the water, there are fifteen with a total excess of 259·63, and a resulting gain of temperature of 35·36. Also those in which the air appeared to be colder than the water were five, giving a total deficiency of 65·5 with a loss of temperature 4·71. Hence $\frac{65 \cdot 5 - 5x}{4 \cdot 71} = \frac{259 \cdot 63 + 15x}{35 \cdot 36}$, whence $x = 4 \cdot 418$, which must be added to the indications of the thermometer registering the temperature of the air. After this correction has been made, it will be found that the effect of a difference of temperature between the air and water, of 9·216, is unity.

4·418 added to 397·226 gives 401·644 for the corrected temperature of the air in the thermal experiments, and this being 7·238 in excess of the temperature of the calorimeter, the corrected thermal effect will be $22 \cdot 0914 - \frac{7 \cdot 238}{9 \cdot 216} = 21 \cdot 306$, which, after applying the needful correction for the immersed portion of the thermometer stem, becomes ultimately 21·326.

The thermal capacity of the calorimeter was made up of 95525 grains of distilled water, 26220 grains of copper, equivalent to 2501 grains of water,

and the thermometer and coil equivalent to 80 grains, giving a total capacity equal to 98106 grains of water. 12·951 divisions of the thermometer are equivalent to one degree Fahr.

The dynamical equivalent is the quotient of the work done, by the thermal effect, or

$$\frac{\left\{\frac{k}{2\pi}\mathrm{H}\right\}^2 \tan^2\theta\,\mathrm{R}\,t}{\mathrm{T}}=$$

$$\frac{\left\{\frac{\cdot 62723}{6\cdot 2832}\times 3\cdot 67073\right\}^2\times \cdot 379857\times 33435640\times 2400}{\frac{21\cdot 326}{12\cdot 951}\times 98106}=25335.$$

It appeared to be desirable to diminish the atmospheric influence; I therefore commenced a second series, in which the calorimeter was covered with two folds of cotton wadding. The bulb of the air-registering thermometer was also placed in a small bag made of the same material. In this fresh series each experiment occupied one hour, as I had learned by experience that with my battery arrangement the current would be sufficiently uniform. In fact the highest reading in an experiment was not more than $\frac{1}{30}$ higher than the lowest. There were, evenly distributed through the hour, forty observations of deflection, twenty of the air, and three of the water-thermometer; and the water was stirred forty times. Two minutes were allowed for the complete equalization of temperature previous to the final thermometer reading. The experiments on radiation were also similarly extended.

The coil was the same as that used in the first series. It had a coat of shellac vanish. Five determinations of its resistance were made, using a single Daniell's cell with various resistances included in the circuit. The galvanometer had a coil 17 inches in diameter consisting of nine turns. The results are as follow:—

C_3.	C_2.	C_1.	Temperature of unit.	Temperature of coil.	Resistance of coil in terms of unit.
° ′	° ′	° ′	°	°	
tan 79 39·5	tan 52 33·3	tan 52 9·3	59·25	58·6	1·0192
tan 71 39·5	tan 47 17·06	tan 46 55·6	48·6	48 5	1·0198
tan 70 16	tan 46 18·11	tan 45 57 4	54·68	57·4	1·0194
tan 71 54·33	tan 47 7 66	tan 46 45·93	.. ..	......	1·0198
tan 62 6	tan 41 30·43	tan 41 13·46	.. ..	.. ..	1·0187
Average	......	.... ..	.. ...	.....	1·01938

The average temperature of the calorimeter in the experiments being 13°·55 Cent., and that at which the unit was adjusted 14°·5, the resistance during the experiments must have been 1·01906, which is equal to 33434330 in British measure.

Second Series of Thermal Experiments.

Date.	Deflection.	tan². Deflection.	Temperature of air.	Temperature of water.	Rise of temperature.	Horizontal intensity.
1866.	° ′					
Sept. 21 ...	29 51·68	·329623	397·4	363·42	30·38	3·6668
„ 22 ...	28 58·4	·306585	362·51	348·06	26·95	3·6707
„ 25 ...	29 14·63	·313472	345·19	306·94	29·75	3·6724
„ 26 ...	29 51·46	·329525	370·84	350·64	29·92	3·6644
„ 27 ...	28 54·78	·305064	365·91	361·71	25·88	3·6665
Oct. 5 ...	29 5·05	·309393	380·66	387·57	24·90	3·6612
„ 6 ...	28 22·54	·291761	426·55	392·77	27·40	3·6688
„ 8 ...	28 8·74	·286198	338·49	335·54	24·04	3·6595
„ 19 ...	28 42·81	·300074	398·56	332·35	31·08	3·6659
„ 20 ...	27 40·13	·274910	395·18	361·90	26·08	3·6654
„ 22 ...	26 40·5	·252409	371·72	388·63	19·12	3·6702
„ 23 ...	27 28·1	·270252	320·07	318·09	22·55	3·6638
„ 25 ...	27 9·63	·263230	275·65	286·25	20·98	3·6620
„ 26 ...	27 42·56	·275855	249·75	257·54	22·15	3·6623
„ 27 ...	28 7·84	·285838	245·96	247·27	23·57	3·6641
Average ...	....	·292946	349·63	335·912	25·65	3·6656

Second Series of Radiation Experiments.

Date.	Temperature of air.	Temperature of water.	Rise of temperature of water.
1866.			
Sept. 21	378·84	344·95	3·0
„	390·13	381·34	0·32
Sept. 22	326·32	334·37	−0·43
„	360·71	361·13	−0·41
Sept. 25	330·67	287·94	4·05
„	347·56	326·13	1·59
Sept. 26	352·15	333·12	2·12
„	377·56	368·12	0·70
Sept. 27	355·81	347·9	0·74
„	388·0	375·69	1·31
Oct. 5	376·9	375·04	0·
„	385·8	396·95	−1·15
Oct. 6	402·94	376·47	2·13
„	433·28	411·33	1·52
Oct. 8	319·5	323·51	−0·29
„	356·02	347·79	0·33
Oct. 19	365·08	303·94	5·95
„	398·49	356·29	3·57
Oct. 20	357·9	344·01	1·61
„	395·66	377·40	1·43
Oct. 22	371·24	380·45	−0·95
„	362·7	392·44	−3·18
Oct. 23	297·96	305·0	−0·50
„	334·07	329·05	0·5
Oct. 25	261·67	277·01	−1·26
„	277·59	294·31	−1·86
Oct. 26	233·31	247·61	−1·40
„	264·37	265·97	−0·66
Oct. 27	237·05	234·85	0·1
„	251·15	257·24	−0·65
Average	343·011	335·245	0·6083

The correction to be applied to the thermometer immersed in air as deduced from the above Table is given by $\frac{123{\cdot}66-12x}{12{\cdot}74}=\frac{356{\cdot}65+18x}{30{\cdot}99}$, whence $x=-1{\cdot}1835$. It appears also that a difference beween the temperatures of the calorimeter and air-registering thermometer so corrected, equal to 10·822, gives the unit effect on the former.

Hence the corrected indication of the air-thermometer in the second series of thermal experiments will be $349{\cdot}63-1{\cdot}1835=348{\cdot}4465$. This being 12·5345 in excess of the temperature of the calorimeter, the corrected thermal effect will be $25{\cdot}65-\frac{12{\cdot}5345}{10{\cdot}822}=24{\cdot}4917$, which, after a small further correction for the immersed stem, becomes 24·512.

The thermal capacity in this second series was made up of 95561 grains distilled water, copper as water 2501, thermometer and coil as water 80, and cotton-wool as water 200 grs., giving a total of 98342 grains.

The equivalent, as deduced from the second series, is therefore

$$\frac{\left\{\frac{\cdot 62723}{6{\cdot}2832}\times 3{\cdot}6656\right\}^2\times \cdot 292946\times 33434330\times 3600}{\frac{24{\cdot}512}{12{\cdot}951}\times 98342}=25366.$$

The equivalents obtained in the two foregoing series of experiments are as much as one-fiftieth in excess of the equivalent I obtained in 1849 by agitating water. I therefore instituted a strict inquiry with a view to discover any causes of error, so that they might be avoided in a fresh series. The most probable source of error seemed to be insufficient stirring of the water of the calorimeter. Although agitated so frequently as forty times in the hour, there could be no doubt that, during any intervals of comparative rest, a current of heated water would ascend from the coil, and that if a thin stratum of it remained any time at the top, some loss of heat would result. I resolved therefore to use a fresh calorimeter, and to introduce into it a stirrer which could be kept in constant motion by clockwork.

Another source of error which, though it would be finally eliminated by frequent repetition of the experiments, it seemed to be desirable to avoid, was the hygrometric quality of the cotton-wool which enveloped the calorimeter in the second series of experiments. I therefore sought for a material which did not present that inconvenience. The plan finally adopted was to cover the calorimeter first with tinfoil, to place over that two layers of silk net (tulle), and to finish with a second envelope of tinfoil.

A third source of possible error was the circumstance that the silver-platinum alloy, when made positively electrical in distilled water, is slowly acted upon, an oxide of silver as a bluish-white cloud arising from the metal, while hydrogen escapes from the negative electrode. On this account the coil in the experiments of the last series, as well as the subsequent, was well varnished. But it was found at the conclusion of the experiments that the varnish had in a great measure lost its protecting power. This circumstance gave me considerable anxiety: I was, however, ultimately able, by the following facts arrived at after the thermal experiments were completed, to satisfy myself that no perceptible influence had been produced by it on the results:—

1st. The resistance of the coils, after long-continued use had deteriorated the varnish, was not sensibly less than it was after they had been freshly varnished.

2nd. The coil of the 3rd series was, in the unprotected state, immersed in distilled water, and compared with many hundred yards of thick copper wire, unimmersed, having nearly equal resistance. The result showed that the resistance to the current was sensibly the same whether a single cell or five cells of Daniell in a series were used. Now, had any considerable leakage by electrolytic action taken place, it would have been very much less in proportion in the former than in the latter instance.

3rd. When the coils of the second and third series, in the unprotected state, were placed in distilled water, and made the electrodes of a battery of five cells, the deflection was 40′ of a degree on a galvanometer with a coil of 17 inches diameter composed of 18 turns of wire. This deflection indicates a current of about $\frac{1}{400}$ of the average current in the thermal experiments. In this case the chemical action was distinctly visible, but quite ceased to be so when the electrodes were connected by a wire of unit resistance, so as to reduce the potential to that in the thermal experiments.

4th. The coil of No. 2 series being used as a standard, that of No. 3 series, in the unprotected condition, was immersed, first in water, then in oil. The resistance to the current of five Daniell's cells was found to be sensibly equal in the two cases.

Hence there could be no doubt that the loss of heat during the experiments by electrolytic action could not possibly in any instance have been so great as one-thousandth of the entire effect, and was probably not one quarter of that small quantity; whilst in the larger number of experiments, when the varnish was fresh, it must have been *nil*.

The coil used in the third series of experiments was made by bending four yards of platinum-silver wire double, and then coiling it into a spiral which was supported and kept in shape by being tied with silk thread to a thin glass tube. The terminals were thick copper wires, and the whole was coated with shellac and mastic varnish. The following results were obtained for its resistance. In the first three trials the current was measured by a galvanometer with a circle of nine turns 17 inches diameter, and in the last six with an instrument with eighteen turns of wire. In the first six there was an extra unit of resistance included in the circuit:—

Battery.	Unit.	C_3.	C_2.	C_1.	Temp. of unit.	Temp. of coil.	Resistance in terms of my unit.
		° ′	° ′	° ′	°	°	
One cell, Daniell ..	Mine ..	tan 52 53	tan 37 3·15	tan 37 10·6	63·27	62·78	·98963
Ditto	„ ..	tan 52 24·12	tan 36 29·02	tan 36 37·27	59·03	60·07	·98823
Ditto	Jenkin's	tan 52 3·62	tan 36 6·45	tan 36 14·79	60·88	60·57	·98752
Daniell's cell. Positive metal iron . .	„	tan 50 25·8	tan 35 21·88	tan 35 29·27	59·78	60·46	·98818
Ditto	Mine ...	tan 49 48 12	tan 34 57·36	tan 35 5·62	60·03	60·30	·98754
Ditto	„ ..	tan 48 17·62	tan 34 5·48	tan 34 12·24	60·50	60·88	·98816
Ditto	„	tan 75 28	tan 49 58·6	tan 50 11·98	61·27	61·08	·98863
Ditto	Jenkin's	tan 75 17·25	tan 49 44·93	tan 49 57·51	61 96	61·27	·98871
Ditto	Mine ...	tan 75 59·6	tan 49 18 97	tan 49 33·08	69·35	70·28	·98820
Average	.. ...	.. ..	.. ..	....	.. ...	......	·98831

The above average resistance, reduced to 18°·63 C., the mean temperature in the third series, is ·98953 of the Association unit, or in British measure 32465480.

In the third series, the experiments for the heat of the current, of radia-

tion, and for horizontal magnetic intensity were alternated in such a manner that each class occupied the same portions of the day that the others did. I sought in this way to avoid the effects of any horary change in the humidity &c. of the atmosphere, or in the magnetic force. Of the thirty experiments comprising each class, six were performed at about each of the several hours, 11 A.M., 12¼ P.M., 1½ P.M., 4 P.M., and 5½ P.M.

The calorimeter, protected as already described, was supported on the edges of a light wooden frame. It was carefully guarded against draughts by screens coated with tinfoil placed at a foot distance. The stirrer consisted of a vertical copper rod, to which vanes, on the plan of a screw-propeller, were soldered at four equidistant places. The rod extended 2 inches above the calorimeter, and was there affixed to a light wooden shaft 2 feet long, attached at the upper end to the last spindle of a train of clock-wheels. The weight was 35 lbs., which, falling about 2 feet per hour, produced a continuous revolution of the stirrer at a rate of about 200 in the minute. The action of the stirrer left nothing to be desired. It was started five minutes before an experiment commenced, and kept going until the last observation of the thermometer had been made.

The experiments, as in the second series, lasted one hour, during which were made eight observations of the thermometer immersed in the calorimeter, twenty of the temperature of the air, and forty of the deflection of the galvanometer.

Third Series of Thermal Experiments.

Date.	Deflection.	tan². Deflection.	Temperature of air.	Temperature of water.	Rise of temperature.	Fall of weight.
1867.	° ′					in.
June 28, 12.54 P.M.	28 18·25	·290024	488·660	494·17	25·1	30
„ 28, 5.36	30 56·37	·359310	534·155	524 214	32·08	26
„ 29, 1.30	28 55·45	·305345	509·172	490 13	27·82	27
July 1, 10.30 A.M.	29 41·1	·324949	428 81	425·67	28·52	27
„ 1, 4 24 P.M.	30 19·4	.342107	508·78	467·214	33 05	26
„ 2, 12.45	30 10 12	·337891	405 343	450·73	25·13	26
„ 2, 6.0	30 30 98	·347424	401·822	458·104	24·99	28
„ 4, 1.20	31 23·4	·372299	516·992	452·97	57·98	27
„ 20, 11.11 A.M.	30 21·72	·343170	385·622	394·0	28·98	28
„ 20, 3.45 P.M.	31 37 55	·379241	454·19	430·97	34·92	28
„ 22. 12.36	32 0·6	·390765	482 44	460·621	35 48	30·5
„ 22, 5.21	32 23·47	·402470	493·087	498·573	34·47	28·4
„ 23, 1.7	31 18 43	·369881	465·238	473·167	31·27	28 7
„ 24, 11.0 A.M.	31 4·75	·363299	430·688	448·043	30 24	27·9
„ 24, 4.5 P.M.	30 49·15	·355900	439 007	470·954	28·14	28·2
„ 25, 12 15	32 39 5	·410832	465·354	432·45	38 48	29·4
„ 25, 4.55	33 10	·427129	521·569	486·049	39 72	28·4
„ 26, 12.58	32 33·95	·407920	445·009	464 267	33 61	30
„ 27, 11.13 A.M.	33 1·6	·422590	391·0	419·21	34 46	30
„ 27, 4.14 P.M.	32 58·22	·420777	418·11	446 623	34·09	29·4
Aug. 2, 12.31	31 52 98	·386923	385·876	390·911	33·1	30
„ 2, 5.18	31 53·77	·387325	407·781	422 843	32·25	28
„ 3, 12.56	31 37 18	·379056	453·66	421·948	35·37	29·75
„ 6, 11.18 A.M.	26 34·35	·250162	439·906	435·699	22·32	29·7
„ 6, 3.55 P.M.	28 42·8	·300070	457·145	462·056	25·67	29·6
„ 8, 12.17	29 29·25	·319773	465·586	443·204	29 6	29·7
„ 8, 5.45	29 39·25	·324137	499·874	480·564	29·67	28
„ 9, 1.27	29 33·2	·321491	478·658	469·296	28 8	26·4
„ 10, 11.9 A.M.	29 12·65	·312625	468·344	455 304	28·21	27·4
„ 10, 3.56 P.M.	28 14·47	·288500	519·082	493·136	27·28	28·4
Average	......	·3517795	458·690	455·436	31·02666	28·362

Third Series of Radiation Experiments.

Date.	Temperature of air.	Temperature of water.	Rise of temperature.	Fall of weight.
1867.				
June 28, 10.38 A.M.	460·527	481·990	−1·48	31
,, 28, 3.53 P.M.	513·687	506·770	0·75	28·2
,, 29, 11.55 A.M.	493·088	473·930	1·82	28
,, 29, 4 40 P.M.	526·185	508·480	1·88	28·5
July 1, 1·23	469·368	442·114	2·46	27·5
,, 2, 10.58 A.M.	404·842	439·790	−2·82	27
,, 2, 4·5 P.M.	401 779	450·930	−4·1	28·5
,, 4, 11.46 A.M.	492·210	427·517	5·97	28
,, 4, 4.42 P.M.	541·007	484·927	5·1	26·5
,, 20, 1.0	416·237	409·044	1·03	28·75
,, 22, 11.5 A.M.	474·393	439·140	3·32	30
,, 22, 3.50 P.M.	486·267	480·106	0·8	28·75
,, 23, 11.41 A.M.	451·029	456·947	−0·1	28·4
,, 23, 4.49 P.M.	475·319	486·113	−0·65	28·5
,, 24, 12.54	441·677	460 780	−1·48	26·5
,, 25, 10.40 A.M.	435·863	410·237	2·43	28
,, 25, 3.27 P.M.	515·653	460·939	5·03	28·8
,, 26, 11.29 A.M.	441·256	447 526	−0·2	28·5
,, 26, 4.49 P.M.	435·776	472·503	−3·0	29
,, 27, 1.7	404·58	433·444	−2·28	29·8
Aug 2, 10.55 A.M.	369·966	374·18	−0·15	29·75
,, 2, 3.50 P.M.	407 34	406 42	0·17	27·8
,, 3, 11.30 A.M.	435·813	401·187	3·24	28·6
,, 3, 4.33 P.M.	476·691	446·393	2·9	27
,, 6, 1.15	457·87	447·843	1·05	28·9
,, 8, 10.46 A.M.	442·403	426·304	1·68	29
,, 8, 4 17 P.M.	489·901	463·143	2·42	29·7
,, 9, 11.51 A.M.	466 428	453·149	1·27	26·5
,, 9, 5.37 P.M.	490·308	484·753	0·66	27·9
,, 10, 1.20	502·96	472·469	2·82	28·6
Average	460·6808	451·6356	1·018	28·498

The correction to be applied to the air-registering thermometer, as deduced from the radiation experiments of this third series, is found from $\frac{217\cdot452-10x}{16\cdot26}=\frac{488\cdot807+20x}{46\cdot8}$, whence x, the quantity to be added to the observed temperature of the air in the thermal experiments, $=2\cdot81$. The temperature of the air was therefore virtually 6·073 higher than that of the water. The results also show that the unit of effect on the calorimeter was produced by a difference of temperature of 11·645.

Hence $31\cdot0266-\frac{6\cdot073}{11\cdot645}=30\cdot5051$; and adding ·077 for the unimmersed part of the thermometer stem, the corrected thermal effect in the third series is found to be 30·5821.

The average capacity of the calorimeter was equal to that of 93859 grs. of water, being made up of 91531 grs. distilled water, 22364 grs. of copper, 486 grs. of tin (the weight of the coating next the calorimeter), 52 grs. silk net (half that employed), the thermometer, coil, and corks.

Determinations of Horizontal Magnetic Intensity.

Date.	Galvanometer deflection, θ.	Weighing by current-meter, w.	$H=\frac{\cdot 17676\sqrt{w}}{\tan\theta}$.
1867.	° ′	grs.	
June 28, 1.30 P.M.	37 21·42	253·04	3·68334
„ 29, 10.50 A.M.	26 43·06	109·28	3·67114
„ 29, 3.50 P.M.	25 12·56	96·04	3·67964
July 1, 12.25	38 23·56	272·35	3·68144
„ 1, 5.20	38 59·25	284·95	3·68634
„ 2, 1.40	38 49·94	280·9	3·68034
„ 4, 10.45 A.M.	26 24·55	106·25	3·66894
„ 4, 3.45 P.M.	26 10·55	104·99	3·68474
„ 20, 12 Noon.	39 18·9	289·875	3·67484
„ 20, 4.40 P.M.	41 11·35	332·825	3·68504
„ 22, 1.30	41 21·4	335·13	3·67594
„ 23, 10.45 A.M.	32 5·1	169·616	3·67194
„ 23, 3.45 P.M.	31 56·15	168·608	3·68224
„ 24, 11.51 A.M.	39 52·95	301·591	3·67364
„ 24, 5·0 P.M.	40 24·9	315·092	3·68474
„ 25, 1.10	41 27·95	338·391	3·67964
„ 26, 10.30 A.M.	34 40·45	206·658	3·67324
„ 26, 3.33 P.M.	33 25·5	188·675	3·67864
„ 27, 12 Noon.	43 19·55	386·0	3·68194
„ 27, 5·12 P.M.	42 48·53	372·658	3·68414
Aug. 2, 1.30	41 15·35	332·733	3·67584
„ 3, 10.25 A.M.	34 13·9	198·99	3·66464
„ 3, 3.33 P.M.	33 40·3	191·983	3·67628
„ 6, 12.12	35 9·8	214 117	3·67156
„ 6, 4.50	37 8·1	248·258	3·67784
„ 8, 1.11	37 44·55	259·867	3·68110
„ 9, 10.53 A.M.	31 23·65	160·708	3·67186
„ 9, 4.42 P.M.	30 43 4	152·75	3·67590
„ 10, 12.12	36 25·4	235·433	3·67557
„ 10, 4.50	34 49·5	209·608	3·67864
Average	....	....	3·67771

The equivalent deduced from the third series is therefore

$$\frac{\left\{\frac{\cdot 62723}{6\cdot 2832}\times 3\cdot 6777\right\}^2\times\cdot 35478\times 32465480\times 3600}{\frac{30\cdot 5821}{12\cdot 951}\times 93859}=25217.$$

The equivalents above arrived at are:—

From Series 1. Average of 10, 25335.
From Series 2. Average of 15, 25366.
From Series 3. Average of 30, 25217.

The extra precautions taken in the last Series entitle the last figure to be taken as the result of the inquiry. Reduced to weighings *in vacuo* it becomes 25187.

NOTICES AND ABSTRACTS

OF

MISCELLANEOUS COMMUNICATIONS TO THE SECTIONS.

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MATHEMATICS AND PHYSICS.

Address by the President, Sir W. Thomson, *LL.D., F.R.S.*

The progress of mathematical and physical science during the past year will be better represented by the valuable reports to be laid before this Section, and the lines of thought which have originated since the British Association last met will be better illustrated by the papers and discussions which will constitute our ordinary daily work, than by any statement which I could have prepared. It was therefore my intention not to detain you from the interesting subjects and abundant matter for discussion which will so fully occupy our time during the Meeting, by an introductory address. But I must ask you to bear with me if I modify somewhat this resolution in consequence of a recent event which, I am sure, must touch very nearly the hearts of all present, and of very many in all parts of the world, to whom the name of Faraday has become a household word for all that is admirable in scientific genius. Having had so short a time for preparation, I shall not attempt at present any account of Faraday's discoveries and philosophy. But, indeed, it is very unnecessary that I should speak of what he has done for science. All *that* lives for us still, and parts of it we shall meet at every turn through our work in this Section. I wish I could put into words something of the image which the name of Faraday always suggests to my mind. Kindliness and unselfishness of disposition; clearness and singleness of purpose; brevity, simplicity, and directness; sympathy with his audience or his friend; perfect natural tact and good taste; thorough cultivation:—all these he had, each to a rare degree; and their influence pervaded his language and manner, whether in conversation or lecture. But all these combined, made only a part of Faraday's charm. He had an indescribable quality of quickness and life. Something of the light of his genius irradiated his presence with a certain bright intelligence, and gave a singular charm to his manner, which was surely felt by every one, from the deepest philosopher to the simplest child, who ever had the privilege of seeing him in his home—the Royal Institution. That light is now gone from us. While thankful for having seen and felt it, we cannot but mourn our loss, and feel that whatever good things, whatever brightness may be yet in store for us, *that* light we can never see again.

On the alleged Correspondence between Pascal and Newton.
By Sir David Brewster, *K.H., LL.D., F.R.S., &c.*

Sir David Brewster said that he had received from M. Chasles several of Newton's letters or notes, which he supposes to be genuine. He would only read one or two observations tending to show that this was a gigantic fraud—the greatest, he be-

lieved, ever attempted as connected with science or literature. Sir David then read the following notes:—1. The correspondence was founded on the assumption that Newton was a precocious genius, having written on the Infinitesimal Calculus &c. at the age of eleven, whereas he was then at school and knew nothing of mathematics, occupying himself only with waterwheels, windmills, waterclocks, and other boyish amusements. 2. There is no evidence that Pascal and Newton had any correspondence. Having examined the whole of Newton's papers in the possession of the Earl of Portsmouth, I never found any letter or paper in which Pascal is mentioned. 3. The letters from *Miss Hannah Ayscough*, Newton's mother, bear this signature, although at the time they were written she was a married woman and should have signed *Hannah Smith*. 4. The letters of Pascal have been found by M. Faugere to be in another hand, and the signature not that of Pascal. 5. The letters and signatures of Newton are not in his hand. 6. An experiment with coffee is mentioned in one of the letters of Pascal, whereas coffee was at that time unknown in France. 7. All Newton's letters are in French, a language in which he never wrote. His letters to the celebrated French mathematician, Varignon, are in Latin, and Newton himself has stated that he could not read French without a dictionary. 8. The style and sentiments in Newton's letters are such as he never could have used. He expresses *eternal* gratitude to Pascal, a word which no Englishman would have employed. 9. According to the correspondence, M. Desmaizeaux got access to Newton's papers after his death, and carried off a great many of them. Now it is certain that Mr. Conduitt, Newton's nephew, arranged and examined all Newton's papers after his death in order to obtain materials for a life of him, and, having failed to find a competent person to write it, he undertook it himself, and obtained from persons then alive all the information that existed respecting Newton's early life and studies. All this information, which I have used in my life of Newton, stands in direct contradiction to the assumption of Newton's precocity and early connexion with Pascal, which is the basis of the correspondence now exciting so general an interest. There can be no doubt, therefore, that the letters of Newton and Pascal are audacious and elaborate forgeries, calculated and intended to transfer to Pascal the glory of the discovery of the law of gravitation and other discoveries which we owe to Newton.

On the alleged Correspondence between Newton and Pascal recently communicated to the French Academy. By T. ARCHER HIRST, *F.R.S.*, *F.R.A.S.*

The author stated that the alleged correspondence between Newton and Pascal, recently communicated to the French Academy by the eminent geometer and historian Michel Chasles, had taken the scientific world by surprise. If genuine, it would follow that it is to Pascal and not to Newton that we are indebted for the development of the theory of gravitation; that Newton borrowed his ideas from Pascal, and, what is worse, basely concealed and tried to cancel all traces of his having thus borrowed. Charges so grave as these could not for a moment be entertained by Englishmen, were they not put forward by one whose authority is acknowledged, and whose rectitude of character is beyond suspicion.

The real history of these documents appeared to be unknown to their present owner, nor was M. Chasles at liberty even to state by whom they were consigned to him. We were deprived, therefore, of the most direct way of testing their authenticity, and must have recourse to examination of the documents themselves. With a view of enabling us to do so, M. Chasles had kindly sent to Sir David Brewster and to the author of the present communication several specimens, in French, of Newton's handwriting, all which had at once been pronounced to be forgeries by the eminent biographer of Newton.

After drawing attention to several inconsistencies contained in the letters already published by Chasles and purporting to be from Pascal, Newton, Boyle, Aubrey, and others, the author stated that the question of authenticity could only be conclusively decided by a careful comparison of the documents with the authentic papers of Newton now in the possession of Lord Portsmouth, the Earl of Macclesfield, the Royal Society, and Trinity College, Cambridge. This comparison would be much facilitated, and, indeed, scientific literature greatly enriched, if the owners of

these papers would generously permit photographic copies to be taken. The national manuscripts of England and Scotland have already been admirably photozincographed by Sir Henry James. The manuscripts of Newton, which are also national, certainly deserve to be transmitted to posterity in like manner.

Mathematics.

On the Inverse Problem of Coresolvents. *By the* Hon. J. Cockle, *M.A., F.R.S.* *Communicated by the* Rev. Professor R. Harley, *F.R.S.*

Inverse problems, as is well known, present greater difficulties than direct ones. For instance, while it is easy to square a number, it is not so easy to extract its square root. Moreover, there are cases in which it is impossible to obtain a finite solution of an inverse problem. The solution of a quintic is usually considered to be such a case. In the theory of coresolvents it is comparatively easy to pass from the algebraical to the differential resolvent, but the converse does not hold. The finite integration of the linear differential resolvent of a given algebraical equation would, perhaps, be a step towards the general solution of the inverse problem. But that integration has not yet been effected, except in two or three special cases; and the definite integrals of Boole have not, that I am aware of, been converted into indefinite ones. In order to take the step above pointed to, it seems to me necessary to have recourse to a non-linear differential resolvent, to be constructed as follows:—The elements of the final non-linear are three; the first is (1) the second differential coefficient of the dependent variable; the second is (2) the first differential coefficient of that variable; the third is (3) the square of the second element divided by the dependent variable itself. The sinister of the non-linear resolvent is constituted by the six homogeneous quadratic products of the three elements, and is the sum of those six products, each multiplied into an indeterminate or conditional multiplier. Each element and each product is, as we know by the theory of coresolvents, in general capable of being expressed as a rational and integral function of the dependent variable, of a degree less by one than that of the given algebraic equation. Suppose this last equation to be a quartic, then each product, and consequently the dexter of the non-linear resolvent, can be expressed as a cubic function of the dependent variable. Let the dexter of the non-linear be reduced to zero by causing the several coefficients of the cube, the square and the first power of the dependent variable, and also the absolute term, to vanish separately. These four conditions, while they reduce the dexter of the non-linear to zero, enable us to eliminate four of the indeterminate multipliers from its sinister. No elevation of degree will arise from the elimination, for all these four conditions are linear. The coefficients of the six homogeneous quadratic products on the sinister will now in general be homogeneous linear functions of the two uneliminated, indeterminate multipliers; and, by the solution of a cubic only, the the ratio of these two multipliers can be so assigned as to cause the sinister to break up into linear factors, each factor being a linear and homogeneous function of the three elements. If we apply the exponential substitution to either of these factors equated to zero, the resulting final non-linear differential equations of the first order are of a soluble form. We have thus constructed a soluble non-linear differential resolvent of a general biquadratic. For a cubic we might dispense with one of the homogeneous products, and consequently with one of the indeterminate multipliers; but we should thus be led to a resulting cubic; and it will be better to retain the whole six terms of the sinister. We shall then having only three conditions of evanescence to satisfy on the dexter, be able to break up the sinister into linear factors, as before, by means of a homogeneous cubic in the three remaining disposable indeterminate multipliers. Applying to this last cubic the method of vanishing groups, we see that its solution depends upon the solution of a quadratic equation and the extraction of a cube root only. In the case of a quartic, the integral obtained by the foregoing processes involves two arbitrary constants only, and its nature and extent require further discussion. But it seems

that, by means of the theory of coresolvents, we obtain new methods of solving algebraic equations up to the fourth degree inclusive; and although the above discussion does not embrace equations whose degrees exceed four, it apparently indicates that further results may spring from the study of non-linear differential resolvents.

A list of 5500 *Prime Numbers. By* W. Barrett Davis.

On Finite Solutions of Algebraical Equations. By the Rev. Professor R. Harley, *F.R.S.*

On a certain Cyclical Symbol. By the Rev. Professor R. Harley, *F.R.S.*

The object of this paper was to explain the meaning and use of a certain symbol which the author had employed with advantage in dealing with circular algebraic functions. Some years ago, while engaged on the theory of quintics, the author found that in the transformation and general treatment of the higher equations circular functions occupy a conspicuous place, and play an all-important part; and the author was led, by an attentive consideration of the structure of such functions, to devise a calculus, whereby operations upon them might be materially abridged. The author had since found that his invention had been to some extent anticipated by Vandermonde, in a Memoir on the Resolution of Equations, published by the French Academy in 1771. The author explained the difference between Vandermonde's process and his own, and showed how he had succeeded lately in enlarging the powers of the latter. Examples were given to illustrate the value of the new symbol, not only as an abridged notation, but also, what was more important, as a working instrument or process.

On a Theorem in the Integral Calculus. By Dr. D. Bierens de Haan.

The differentiation of an integral according to a constant under the sign of integration has been extended by Schlomilch to the case of the limits of the integral depending on this constant. Omitting the correction in case of discontinuity, the formula is

$$\frac{d}{d\rho}\int_r^R \phi(\rho, x)dx = \int_r^R \frac{d\phi(\rho, x)}{d\rho}dx + \phi(\rho, R)\frac{dR}{d\rho} - \phi(\rho, r)\frac{dr}{d\rho}. \quad . \quad . \quad . \quad (1)$$

Now an analogous formula should exist for integration under the integral sign. From (1), when R and r are constants in regard to ρ, and so the two last forms vanish, we deduce

$$\int_p^q d\rho\int_r^R f(\rho, x)dx = \int_r^R dx\int_p^q f(\rho, x)d\rho, \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

that is, the theorem for changing the order of integration. In the same manner, from (1) with the two last terms, we deduce, first,

$$\int_r^R\int\phi(\rho, x)dx = d\rho\int_r^R \frac{d\phi(\rho, x)}{d\rho}dx + \int\phi(\rho, R)\frac{dR}{d\rho}d\rho - \int\phi(\rho, r)\frac{dr}{d\rho}d\rho + C;. \quad (3)$$

and afterwards, after some transformations,

$$\left.\begin{aligned}\int_p^q d\rho\int_r^R f(\rho, x)dx &= \int_r^R dx\int_p^q f(\rho, x)d\rho - \int_p^q \frac{dR}{d\rho}d\rho\int f(\rho, R)d\rho \\ &-\int_p^q \frac{dR}{d\rho}d\rho\int F(\rho, R)\frac{dR}{d\rho}d\rho + \int_p^q \frac{dr}{d\rho}d\rho\int f(\rho, r)d\rho \\ &+\int_p^q \frac{dr}{d\rho}d\rho\int F(\rho, r)\frac{dr}{d\rho}d\rho,\end{aligned}\right\} \quad . \quad . \quad . \quad (4)$$

where

$$F(\rho, y) = \frac{\delta\phi(\rho, y)}{\delta y}, \quad \phi(\rho, y) = \int f(\rho, y)d\rho \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (4a)$$

Both formulæ are of use in the integral calculus.

Proof of the Binomial Theorem. By the late JAMES LINDSAY. *Communicated by* W. B. GRANT.

On the Approximate Drawing of Circular Arcs of given lengths. By Professor W. J. MACQUORN RANKINE, *LL.D., F.R.S.*

This paper contains rules for use in mechanical drawing, founded on the principle, that if a straight line and an indefinite number of circles in one plane touch each other at one point, the curve which cuts off parts of a given uniform length from the straight tangent and from all the circles, approximates, in the neighbourhood of the place where it cuts the straight tangent, very closely to a circular arc whose radius is three-fourths of the given uniform length. The arcs laid off according to the rules are somewhat longer than the exact length; but in an arc subtending 30° the error is only $\frac{1}{14800}$ part of the length of the arc; and it varies nearly as the fourth power of the angle subtended by the arc.

ASTRONOMY.

Preparations for Observing the Total Solar Eclipse of August 18, 1868. *By* Major J. F. TENNANT, *R.E., F.R.A.S., F.R.G.S., F.M.S.*

In January last I drew the attention of the Royal Astronomical Society to the Total Eclipse of 1868, August 18, which will be visible in India, and in the March Number of the 'Notices' of the Society will be found a paper in which I proposed that the Government of India should be solicited to make arrangements for making use of this very favourable opportunity for examining the prominences.

I am happy to say that, at the suggestion of the Astronomer Royal, the Secretary of State for India has sanctioned the preparation of an equipment, and I propose in this note to mention what is in progress.

First. It is intended to photograph the appearances of the total phase. For this purpose a $9\frac{1}{4}$-inch "silver-on-glass" reflector, equatorially mounted and driven by clockwork, is being prepared. The photographs will be taken in the focus of the speculum, and it is estimated that the exposure to produce an image of the prominences will not exceed half a second. Provision is being made for a considerable field, in order that, if possible, some record may be obtained of the structure of the corona.

Secondly. It is proposed to examine, as well as may be, the spectra of the prominences and corona. For this, one of the old collimators of the Greenwich Transit Circle has been kindly lent by the Astronomer Royal. It is being equatorially mounted in a rough way, and will be provided with a spectroscope permitting the observations to be referred to the lines of the solar spectrum.

Lastly. The Astronomer Royal has lent a 42-inch telescope, mounted firmly, to which is being adapted an eyepiece for examining the state of polarization of the lights of the prominences and corona. An arrangement is being made by which one test may be rapidly changed for another, and it is hoped that in this way a more satisfactory result will be obtained than by any single test.

I trust that all the instruments will be in India early in next year, and that they will be in position in time to allow experiments to be made, so as to secure the success of the photographic operations.

Light.

On the Colours of the Soap-Bubble.
By Sir David Brewster, *K.H., LL.D., F.R.S., &c.*

The colours of the soap-bubble have been the subject of frequent observation since the time of Boyle, Hook, and Newton, and they have been invariably ascribed "not to any colour in the medium itself in which they are formed, or on whose surfaces they appear, but solely to its greater or less thickness." The author of this paper had been led to doubt the correctness of this opinion, and while repeating the beautiful experiments of Professor Plateau "On the Equilibrium of Liquid Films," he was led to discover the true cause of these colours, whether they are observed on the soap-bubble or on plane, convex, and concave films stretched across the mouths of closed or open vessels.

The paper, which is illustrated with numerous coloured drawings, is divided into five parts.

1. On the phenomena of colour in a vertical plane film.
2. On the production of revolving systems of coloured rings on the soap-film.
3. On the form and movements of the bands and rings on convex and concave films.
4. On the phenomena produced by different solutions.
5. On the origin and development of the colours of the soap-bubble.

In these sections the author has shown that the colouring-matter of the soap-bubble is secreted from the soap-solution when reduced to the state of a film; that it rises to the highest point of the film in colourless portions, in the form of tadpoles, which pass into molecules in every possible order of colour, and then take their proper place in the coloured bands; that these bands move over the surface of the film under the influence of gravity, and may be blown into fragments or into molecules of all colours, or even recombined with the film; that they may be blown into two systems of coloured rings, the one revolving from right to left, and the other from left to right; and that under the the influence of the centrifugal force, these molecules are carried into their place in Newton's scale—those of the first orders going to the centre of the rings, and followed by those of higher orders that happen to be in the film, when it is blown upon through a tube in the direction of a diameter.

"It is impossible," the author adds, "to convey in language an adequate idea of the molecular movements, and the brilliant chromatic phenomena exhibited on the soap-films, and it is equally impossible for art to delineate them. The visible secretion of a colourless fluid from a film less than the twelve thousandth of an inch in thickness,—its separation into portions of every possible colour,—the quick passage of these portions into bands of the different orders in Newton's scale,—their ever varying forms and hues when the bands either break up spontaneously, or are forcibly broken up,—their conversion into revolving systems of coloured rings under the influence of a centrifugal force,—their various motions when the film is at rest, and protected from aerial currents,—their recombination into a colourless fluid when driven to the centre or margin of concave and convex films, and their reabsorption by the film by means of mechanical diffusion, are facts constituting a system of visible molecular actions, of which we have no example, and nothing even approaching to it in Physics."

On the Figures of Equilibrium of Liquid Films.
By Sir David Brewster, *K.H., LL.D., F.R.S., &c.*

In repeating some of the experiments of Professor Plateau, described in seven interesting memoirs published in the Transactions of the Belgian Academy, and in prosecuting his own experiments on the colours of the soap-bubble, the author of this paper observed several new phenomena which may have escaped the notice of the Belgian philosopher.

Professor Plateau has described and drawn the beautiful systems of soap-films, obtained by lifting from a soap-solution a cube made of wires about one and a half inch long. This system is a polyhedron, composed of twelve similar films stretch-

ing from the wires, and united to a plane quadrangular film in the centre. When this vertical film was blown upon, M. Von Rees observed that it was reduced to a line, and then reproduced in a horizontal position, from which it could be blown again into a vertical position.

If we suppose the quadrangular film removed, and all the twelve films radiating from the centre of the cube, Professor Plateau found that such a system could not be kept in equilibrium, unless there was something solid in the central point, such as the end of a wire or a drop of fluid.

In repeating these experiments the author found that, after converting the horizontal into the vertical quadrangular film, and continuing the blowing, he produced the radial system of films, which in an instant returned to the system with a vertical film, and then into the system with the horizontal film.

M. Von Rees had found that, by immersing the wire cube with the normal polyhedron a few millimetres in the soap-solution, the film formed on its lower face, imprisoned the air in the quadrangular pyramid above it, and that this air rose to the centre of the cube, and replaced the quadrangular plane with a hollow cube with curved faces.

In this beautiful experiment the hollow cube is invariable in size, being necessarily equal in its contents to one-fourth part of the wire cube. The author of the present paper discovered a method of inserting a hollow cube of any magnitude in the centre of the polyhedron This was done by blowing a bubble of the requisite size, and introducing it within the wire cube. He succeeded also by this means in inserting a second hollow cube beside the first, the side common to both being plane when the two cubes were equal, convex when the one was less, and concave when it was greater than the other. In such a system, which is in perfect equilibrium, the number of films is *nineteen*. He found also that two hollow solid figures could, by the same means, be inserted in the other systems of films which Professor Plateau had discovered in a wire tetrahedron, or a quadrangular pyramid, or a regular octahedron, or a rectangular prism, or in a system obtained from two rectangular planes fixed at right angles to each other.

This last and interesting system consists of four curved films extending from each vertical wire, and connected with an elliptical film in the common section of the rectangles. The major axis of this film is four times greater than its minor axis, and it is placed in the angle, which is a little greater than 90°, but sometimes also in the other angle.

By making this system of wires moveable, so that the rectangular planes can pass from 90° to 180°, the author obtained some singular results. As the angle increased from 90°, the minor axis of the elliptical film increased, till when it approached to 180° it was nearly circular, appropriating gradually the fluid of the four curved films attached to the wires.

By again diminishing this angle the almost circular film became more and more elliptical, till it reached its normal state at 90°, giving back to the curved films the fluid which formed them. If the angle of the rectangular plane which contains the elliptical film is diminished, the film will grow more elliptical, and at 45° will become a straight line, giving up its fluid to the other four films. At this instant the whole system changes, the oval film being reproduced in the angle of 135°!

Remarkable as this phenomenon is, there is one still more remarkable, which requires the testimony of the eye to make it credible. If when the rectangles are inclined 90° we blow upon the elliptical film a bubble of such a size as to replace the system of films with a hollow curvilineal cube, and wait till it bursts, *the system of liquid films which it expelled will reappear, as if it had left its ghost behind it to recover the elements which the bubble had appropriated*!

By uniting the upper and lower ends of all the wires in this system, and also by uniting the wires at various points in their length, the author obtained a number of beautiful and complex systems of films, which require numerous diagrams to make them intelligible.

After treating of the equilibrium of liquid films, as seen in the union of spherical bubbles and other hollow solids, the author considers the formation of plane, convex, and concave films upon the mouths of open and closed vessels of different shapes, and their deposition on the same vessels from bubbles; and he describes

various remarkable movements of the films, upwards and downwards, when they are formed upon conical vessels open at both ends.

Notice respecting the Enamel Photographs executed by Mr. M'Raw, of Edinburgh. By Sir DAVID BREWSTER, *K.H., LL.D., F.R.S., &c.*

In order to give permanence to photographs, various attempts have been made to burn them into glass or porcelain. M. Joubert and M. Lafon-Camersac some time ago produced very fine pictures by this process; and more recently, M. Obermetter and M. Grune, of Berlin, have been equally successful. Our countryman, Mr. William M'Raw, has also succeeded in obtaining very excellent pictures, which will bear comparison with those produced by the best foreign artists, and he has requested me to exhibit specimens to the Section. Mr. M'Raw believes that his process is similar to that of Camersac, which is kept secret, and he claims no other merit than that of being the first British artist who has succeeded in this branch of photography. His pictures are produced in any enamel colour, and although, before they are fired, they can be rubbed off like daguerreotype, yet the burning fixes them immoveably, while the fusion of the picture gives it its characteristic transparency. From some experiments which he has already made, Mr. M'Raw is sanguine that the pictures may not only be produced in monochrome, but that they may be simply tinted and finished with the various colours burned in. Although the specimens are chiefly on glass, yet they can be transferred to any surface or substance that will stand the firing, such as enamelled copper articles of porcelain.

On the Motions and Colours upon Films of Alcohol, Volatile Oils, and other Fluids. By Sir DAVID BREWSTER, *K.H., F.R.S., &c.*

In a paper "On the Phenomena of thin Plates exposed to Polarized Light," published in the Philosophical Transactions for 1841, the author observed certain motions and colours upon some of the volatile and fixed oils, the cause of which he did not attempt to discover. Their apparent similarity to the molecular movements and colours, described in a preceding paper, induced him to resume the subject.

When a drop of alcohol is placed upon an aperture the fifth of an inch in diameter or less, a concave lens will be formed upon it. As the alcohol evaporates, a very small plane film will appear in the centre, and will gradually increase till it fills the aperture. If held in a vertical or even inclined position, and examined by transmitted light, a current of fluid, without colour, will be seen issuing from the margin of the film, moving quickly to different parts of its circumference, sometimes dividing itself into two currents dancing opposite one another, and then extending into secondary currents in constant motion. Similar currents are produced upon various alcoholic solutions and a large number (seventy to eighty) of volatile oils, &c.

If we now examine the film by reflected light, the principal and secondary currents will be seen as before, but accompanied with systems of coloured rings of great beauty, shifting their place on the film, sometimes in rotation, expanding and contracting quickly, and changing their form and colour.

In small films there is often only one system of rings contracting and expanding with a constant variation of the central tint. In general, however, there are two, three, or several systems—each system being produced by a secondary current giving motion to the colouring-matter on the surface of the film. In some cases the motions and colours disappear, the film becomes colourless, and tadpoles issue from its margin as on the soap-bubble; but in general the film bursts before this takes place. The colourless currents and the colours into which they expand are supposed by the author to have the same origin as those upon the soap-bubble. The paper was illustrated by drawings of the currents and of the systems of rings.

On the Radiant Spectrum. By Sir DAVID BREWSTER, *K.H., LL.D., F.R.S., &c.*

I have given the name of *Radiant Spectrum* to a phenomenon which I discovered in 1814, and which I described to the Royal Society of Edinburgh in the early part of that year.

It will be understood from fig. 1, which represents the brilliant radiation which surrounds a very small image of the sun, when it is formed either by reflection or refraction, or otherwise.

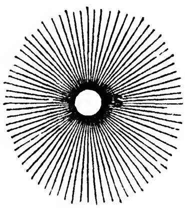


Fig 1.

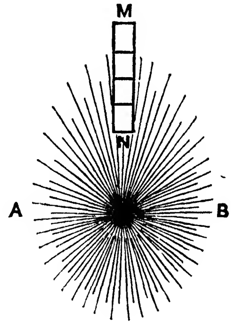


Fig 2.

Fig. 6.

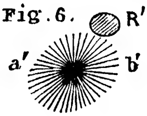


Fig. 3.

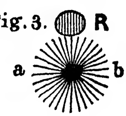


Fig. 7.

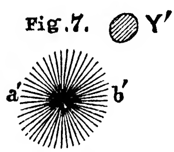


Fig. 4.

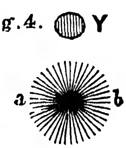


Fig 8

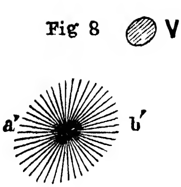


Fig 5.

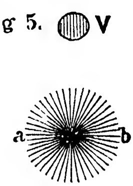
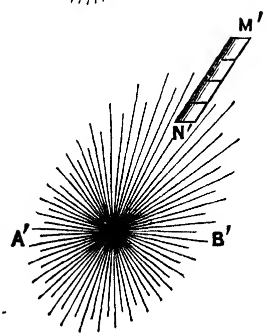
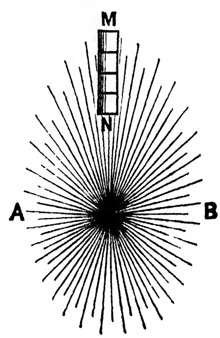


Fig 9.





If we now form a spectrum of this radiant image, either by a prism or by diffraction, we shall have the *radiant spectrum* shown in fig. 2, where MN is the

spectrum of the small circular image S, and AB the spectrum of the radiation, the centre of which is beyond the violet, and nearly in the place where the intensity of the chemical or invisible rays is a *maximum*.

In order to analyze this compound radiation, let the image of the sun S, fig. 1, be taken from homogeneous *red* light R, fig. 3, and refracted by the prism, and we shall have its radiation *ab* at a little distance from the bright portion R, as in fig. 3. In homogeneous *yellow* light (Y, fig. 4) the radiation *ab* will be at a greater distance from Y than in the *red* light. In homogeneous *violet* light (V, fig. 5) the radiation *ab* will be at a greater distance from V than in the *yellow* light.

If we now refract laterally these homogeneous radiant spectra, fig. 3 will be changed into fig. 6, fig. 4 into fig. 7, and fig. 5 into fig. 8, thus proving that the radiant portion of the spectra consists of rays more refrangible than the portion RY and V from which it is derived, and that the difference between the refractive indices of these portions increases with the refrangibility of the rays at RY and V.

The compound spectrum MN, AB, fig. 2, is therefore composed of all these separate spectra, and if we refract it laterally, as shown in fig. 9, we produce the oblique radiant spectrum M'N'A'B', thus proving that the radiant image consists of rays more refrangible than the homogeneous light from which it is derived.

In a rude experiment with a prism of flint glass, whose mean index of refraction was 1·596, the index of the extreme violet was 1·610, and that of the centre of the radiant image 1·640.

In the preceding experiments the radiation is produced by the action, on the retina, of the small and bright image of the sun; but the same results are obtained, and more distinctly exhibited, by placing a surface of finely ground glass either on the front of the prism, or behind it, and near the eye.

The existence of a radiant image beyond the violet end of the spectrum, as in fig. 2, is a fact difficult to explain. I have had an opportunity of describing, or showing it to several distinguished philosophers—to the Marquis Laplace and M. Biot in the autumn of 1814, and more recently to others, by some of whom the experiments have been repeated, but no explanation of them has been suggested, excepting the untenable one that the separation of the radiant image from the ordinary spectrum might be the result of parallax.

A better theory, and one of great interest, if true, may be sought in the phenomena of fluorescence, discovered in sulphate of quinine by Sir John Herschel, and in fluor spar and other substances by myself, and in the beautiful explanation of them by Professor Stokes. In this theory the invisible radiation of the chemical rays is rendered visible by being scattered by granular surfaces, just as the invisible chemical rays in the ordinary spectrum are rendered visible by being reflected and scattered by the particles of fluorescent bodies.

On the Laws of Symmetry of Crystalline Forms. By A. R. CATTON.

A contribution towards the expression of the angle between the Optic axes of a Crystal in terms of the angles between the faces. By A. R. CATTON.

On the Theory of Double Refraction, with special reference to the influence of the Material Molecules on the propagation of Light in Crystals. By A. R. CATTON.

On a Mechanical Means of producing the differential motion required to equalize the focus for the different planes of a solid. By A. CLAUDET, *F.R.S.**

A New Fact of Binocular Vision. By A. CLAUDET, *F.R.S.*

Photographic Portraits obtained by Single Lenses of Rock Crystal and Topaz. By A. CLAUDET, *F.R.S.*

* See Proceedings of the Royal Society, 1867.

On a Real Image Stereoscope. By J. CLERK MAXWELL, *M.A., F.R.S.*

In all stereoscopes there is an optical arrangement, by which the right eye sees an image of one picture and the left eye that of another. These images ought to be apparently in the same place, and at the distance of most distinct vision. In ordinary stereoscopes these images are virtual, and the observer has to place his two eyes near two apertures, and he sees the united images, as it were, behind the optical apparatus. In the stereoscope made for the author by Messrs. Elliott Brothers the observer stands at a short distance from the apparatus, and looks with both eyes at a large lens, and the image appears as a real object close to the lens. The stereoscope consists of a board about 2 feet long, on which is placed, first, a vertical frame to hold the pair of pictures, which may be an ordinary stereoscopic slide, turned upside down; secondly, a sliding piece near the middle of the board containing two lenses of 6 inches focal length, placed side by side, with their centres about $1\frac{1}{4}$ inch apart; and thirdly, a frame containing a large lens of about 8 inches focal length and 3 inches diameter. The observer stands with his eyes about 2 feet from the large lens. With his right eye he sees the real image of the left-hand picture formed by the left-hand lens in the air, close to the large lens, and with the left eye he sees the real image of the other picture formed by the other lens in the same place. The united images look like a real object in the air, close to the large lens. This image may be magnified or diminished at pleasure by sliding the piece containing the two lenses nearer to, or further from, the pictures.

Experiments on the Luminosity of Phosphorus. By J. MOFFAT, *M.D.*

HEAT.

On some Deductions by Dr. Tyndall from his recent Experiments regarding the Radiant and Absorptive Properties of Vapour in the Atmosphere. By R. RUSSELL.

After referring to the importance of Prof. Tyndall's researches on heat as a mode of motion, the author took exception to some of his deductions on the influence which the vapour of water exerts in modifying the intensity of solar and terrestrial radiation. The author stated that he had come to the conclusion that the radiant powers of the vapour of water in the atmosphere were not even capable of forming clouds, though they might be capable of forming mists in valleys. In our atmosphere he believed that the vapour of water has little power of transmitting its heat into space when it approaches or reaches the dew-point, and that if any cloud had been caused by the radiation of heat into space, its upper surface would be flat, like the mists in the meadows before sunrise. These and other reasons led him to the conclusion that the radiation of vapours into space has, directly, a very slight influence on the production of rain.

On a New Telegraphic Thermometer, and on the Application of the Principle of its construction to other Meteorological Indicators. By C. WHEATSTONE, *F.R.S., D.C.L., LL.D., &c.*

The telegraphic thermometer which I constructed in 1843, and which is described in the Report of the Thirteenth Meeting of the British Association, depended on the simultaneous action of two isochronous chronometer or clock movements—one at the remote station regulating the motion of a plunger in the bore of a thermometer, and the other at the near or observing station, marking, by the motion of the needle of a galvanometer, the moment at which the contact of the plunger with the mercury of the distant thermometer completed or broke the circuit. The clock movements required to be periodically wound up, and therefore the affected instrument could not be left to itself for an indefinite time.

There are, however, many situations in which it might be desirable to have meteorologic indications when the instruments would not be accessible for very

long periods. I have therefore devised a new class of telegraphic meteorometers which shall be independent of clockwork, and may remain in any situation of difficult access as long as the instrument endures. This principle is applicable to all instruments which indicate by means of a revolving hand, and I have already devised its application to a Breguet's metallic thermometer, an aneroid barometer, and an hygrometer, depending on the absorption of moisture by a thin membrane. It is also applicable to a bar-magnet in a fixed position, and to a variety of other indicators.

The apparatus consists of two distinct instruments, connected only by telegraphic wires: the first I will call the questioner (A); the second, the responder (B).

The questioner (A) is a rectangular box presenting externally a circular dial face, round which are engraved the degrees both of the Fahrenheit and Centigrade thermometric scales; the former ranging from 20° below zero F. to 220° above that point, and the latter from 0° to 110° C. It shows besides three binding screws for the purpose of connecting the telegraphic wires, and a handle which causes the rotation of the armature of a magnetomotor in the interior. This magnetomotor is similar in its construction to that employed in my alphabetic magnetic telegraph; a soft iron armature rotating before the four poles of the magnet occasions, when the circuit is completed, alternate currents of equal intensity. The box also contains a small electromagnet which acts by means of mechanism similar to that employed in the indicator of the aforesaid telegraph, and causes the revolution of the index of the dial.

The responder (B) is a cylindrical brass box which presents on its upper surface a similar dial with its thermometric scales and index; at its base three binding screws, corresponding to those of the questioner, are fixed for connecting the telegraphic wires, and it is furnished with a brass cover that it may be hermetically sealed when lowered in the sea or buried in the ground. Its interior contains three essentially distinct parts:—1. The metallic thermometer, which consists of a spiral ribbon of two dissimilar metals, with its hand capable of ranging through the extent of the circular thermometric scale of the dial. 2. A small electromagnet, acting by means of a propelment on a disk, making as many stops in one rotation as there are half degrees on the scale. 3. An axis, to which is fixed a delicate spiral spring which causes a pin to bear lightly against the hand of the thermometer, however it may vary in position.

The two instruments are connected by means of two telegraphic wires. The first proceeds from an earth-plate at the near station, passes through the coil of the electromotor in A, joins the coil of the small electromagnet in B, and then proceeds to another earth-plate at the distant station. The second wire is permanently connected with the first between the earth-plate and the coil of the magnetomotor, and includes that of the electromagnet in B, and its opposite end is brought close to the remote end of the first wire. The mechanism is so disposed that when the first wire is disconnected from its earth terminal it is brought into circuit with the second wire.

By this arrangement, when the dial of A is brought to 0° and the handle turned, at the first moment the circuit is completed through the first wire, containing the coil of the electromagnet in B, and the return earth. A disk is thereby caused to revolve in an opposite direction to the graduation of the scale, until a pin, originally starting from 0°, comes into contact with the pin pressing against the thermometer hand, and thereby completes the circuit of the second wire and breaks the connexion with the earth-plate. At first only the electromagnet in B is acted upon, but when the currents are diverted into the new channel, both the electromagnets act simultaneously. In consequence of the action of the electromagnet in A the hand of its dial passes over a space corresponding with that between 0° and that indicated by the thermometer, and the hand of the dial ultimately accords with that of the distant thermometer. When the hand of the dial on A comes to rest, the disk in B arrives at 0°, and a catch permits the spiral spring to unwind itself, and its pin flies to and presses against the thermometer hand.

It must be observed that instruments thus constructed are not capable of marking every possible gradation; but they may be made to indicate divisions of the scale of any required minuteness. It is advisable to limit the extent of the scale when more minute divisions are deemed necessary.

The only circumstance that can affect the accuracy of the indications of the instrument is this. The pin pressing against the thermometric index displaces it a little, and causes it to assume a position about a degree in advance; but as this pressure is a constant one, the inconvenience is remedied by a slight corresponding shifting of the scale.

Electricity, Magnetism.

On the Electric Induction of Mr. Hooper's Insulated Wires, compared with Gutta-Percha Insulated Wires, for Telegraphic Cables. By William Hooper.

The author referred to the relation existing between the different properties of insulated wires arising from induction. He showed by an extensive series of experiments that an intimate connexion exists between the effects of electrification and electrostatic induction, and that the penetration of electricity into the substance of an insulator, when measured by the residual discharge, is a function of the electrostatic capacity, and not simply of resistance. He has also shown that the effects of electrification are increased nearly in the same proportion as the interior inductive action is reduced.

On a new form of Dynamo-Magnetic Machine.
By William Ladd, *F.R.A.S.*

Siemens and Wheatstone have shown that the residual magnetism left in soft iron, after being under the influence of a battery, or permanent steel magnets, can be augmented from the currents generated by itself, by merely applying dynamic force to the revolving armature containing a coil of copper wire, the terminals of which are connected with the wire surrounding the electromagnet, but although great effects were produced *in* the electromagnet, the current itself could only be made available by its partial or total disruption—in the former case diminishing the power of the electromagnet, and in the latter reducing it to its normal condition. The author has constructed a machine, in which the power of the electromagnet is kept up, whilst a separate current, to be applied to any useful purpose, can be drawn off by means of an independent arrangement. The machine consists chiefly of two plates of iron; to both ends of each plate is fixed a portion of a hollow cylinder; these plates are then placed a certain distance apart, and insulated from each other, in such a manner that the cylindrical pieces form two hollow circular passages; into these spaces two Siemens's armatures are placed.

The plates are surrounded by coils of stout copper wire connected together, the two terminals being brought into connexion with the commutator of the smaller armature, so that each change of polarity in the armature will augment the power of the electromagnet. When the machine is first made, it is only requisite to pass a current from a small voltaic cell for an instant, to give the iron a polarity, it will then retain a sufficient amount of magnetism for all future work.

If the armature in connexion with the electromagnet is made to rotate, there will be a very feeble current generated in it; this, passing round the electromagnet, will increase its power with every additional impulse. It will thus be seen that the only limit to the power of the machine is the rapidity with which the armature is made to rotate, which is entirely dependent on the amount of dynamic force employed; but the great improvement in this machine is the introduction of the second armature, which, although it takes off very powerful currents generated in its wire by the increased magnetism, does not at all interfere with the primary current of the electromagnet. The machine exhibited in the Paris Exhibition measures about 24 in. in length, 12 in. in width, and stands 7 in. high, which, notwithstanding its imperfect proportions, is capable of keeping 56 in. of platinum wire, ·01 in. diameter, incandescent, when a small voltameter was placed in circuit would give off 250 cubic centimetres of gas per minute; and in connexion with an

electric regulator would yield a light equal to about 35 Grove's or Bunsen's elements, the driving-power expended being less than one horse.

I have also constructed another form of machine, on the same principle as that described above, but instead of having two independent armatures running in separate grooves, they are fixed end to end, so as to appear like one continuous armature, but so placed with reference to each other that their magnetic axes shall be at right angles. By this arrangement there is only one opening required for the armature, enabling full advantage to be taken of the horseshoe form of electromagnet. The shoes of the electromagnet and armatures are so proportioned to each other that there is an actual break in the magnetic circuit with reference to each armature alternately, but by their disposition at right angles there never is an actual break in the complete magnetic circuit; simply a shifting occurs of the principal portion of the magnetic force from one armature to the other at the precise moment required to produce the best effect. The mechanical advantages to be obtained by this disposition of parts must be at once obvious, as one pair of bearings and a set of driving gear are dispensed with, and from the fixing of the two armatures together the currents are made to flow perfectly isochronous with each other. It may be found advantageous to vary the angle of position of the armatures with reference to each other, according to the speed at which they are driven, so that the current given off by the exciting armature may at the precise moment exert its full effect upon the electromagnet, and thus produce the best effect in the second armature.

On a Magneto-Electric Machine. By WILLIAM LADD, *F.R.A.S.*

On the Phenomena which occur when Magnetized Steel is dissolved in Acids. By DR. T. L. PHIPSON.

Notice of a proposal to illuminate Beacons and Buoys by Electricity, conveyed through Submarine Wires connected with the Shore. By T. STEVENSON, *F.R.S.E., M.I.C.E. With a description of the Induction-Spark Apparatus used for this purpose in the first experiments made for the Northern Lights Board, also the Electrical Apparatus recently designed for the Northern Lights, by* C. W. SIEMENS, *F.R.S.*

The great expense of such lighthouses as the Eddystone and Bellrock has rendered it necessary for the sailor to be contented in many places of danger with a simple beacon or floating buoy, which, being invisible at night, ceases to be useful at the very time of all others when a guide is most needed. Various expedients for lighting these sea-marks, such as camphine lamps and phosphorescent oils capable of emitting a dull light in the dark, have been proposed. In January 1854 I proposed in Trans. Roy. Scot. Soc. Arts to lay gas-pipes between the shore and the beacon and "submarine electric wires for illuminating a lantern placed in a beacon or buoy." As stated in that paper, however, "I dismissed such schemes from my mind; for independently of many other difficulties attending them, they are open to one ground of objection, which, at least in the present state of our knowledge, seems insurmountable. This is based on what may be called an axiom in lighthouse engineering, viz. that it is better to exhibit no light at all than one which is liable to be often extinguished."

Under these circumstances I at that time suggested an entirely different method of illuminating beacons, namely, a beam of parallel rays of light projected from the shore upon optical agents placed upon the beacon at sea, and capable of spreading the rays over any required angle in azimuth, so as to produce a mock or apparent light. This method has been in use at Stornoway Loch without any accident or failure for the last fifteen years. There are, however, certain places where this apparent or mock light is not very suitable, owing to the primary light and reflected light being nearly in line. This consideration, coupled with the improvements which have subsequently taken place in electrical appliances, led me, in 1865, in a report to the Northern Lights Board on the magneto-electric light, to

revert to my former proposal of leading electricity through wires for the illumination of beacons and buoys at sea.

For such a purpose neither Holmes' nor Wilde's light could be employed, as they are produced by the rapid consumption of carbons, and require the employment of lamp machinery, which, though to a large extent automatic, involves the constant presence of a lightkeeper in the lantern. I therefore resolved on employing the simple electric spark, either by itself or in vacuum tubes. After consulting with my friend Professor Swan, who suggested the combination of the Leyden jar with the induction-coil, experiments were made, and in an interim communication to the Scot. Soc. Arts on 13th January 1866, I was able to report that, "by means of four Bunsen cells, an induction-coil, and a Leyden jar, I had succeeded with a simple unaided spark placed in the focus of lighthouse apparatus, to produce an effect at the distance of about half a mile, which was in all respects satisfactory." The light might have been seen much further but for the intervention of obstructions to the view.

The Commissioners of Northern Lights, on the recommendation of Messrs. Stevenson, in their report of 1st February 1866, procured, with the sanction of the Board of Trade, a submarine cable from Messrs. Siemens of London, but as the cable was not suitable for this kind of apparatus, the current could not be passed under the water. Messrs. Stevenson then reported to the Board that, as Mr. Siemens had thought of a different form of apparatus, he should be employed to furnish one. This beautiful arrangement is now exhibited, and Mr. Siemens has kindly sent me a description of its different parts, which I shall afterwards read.

While Mr. Siemens was engaged with this instrument, I received many important suggestions as to the induction-spark apparatus. Mr. Brebner, C.E., suggested that the induction-coil should be placed on the beacon, while the break and batteries should be on the shore. Dr. S. Wright recommended that, instead of one large coil, several coils of small intensity should be used; and Mr. Hart, who conducted all the experiments, and to whose untiring zeal is mainly due whatever amount of efficiency the induction-spark apparatus may possess, added a new contact breaker with two magnets and a double break.

By means of these improvements the light was kept in action during a week at the expense of about 2 shillings for 16 hours, with a current passing through a wire 860 feet long. The light so produced, as viewed from the sea and elsewhere, was perfectly sufficient for the purpose required. It may be added, that of all the metals which I have tried a wire of bismuth produced the brightest spark. The effect might, perhaps, be also increased without using additional cells, if the same currents could be again utilized so as to generate a second spark in the focus.

There can be no doubt that a sufficient light can be obtained either from the induction-spark or from the arrangement of Mr. Siemens, to be afterwards described. Beacon lights, which are needed for pointing out local dangers, do not, of course, require to be of the great power which is needed in lighthouses for illuminating the ocean. In determining which of the two kinds of apparatus should be preferred, the point turns upon which is likely to be the most *certain* in its exhibition. Each method has its own peculiar advantages and disadvantages. In the induction-spark apparatus the contact breaker is on the shore and under control, but, on the other hand, the coils may perhaps not last long. In Mr. Siemens's apparatus the products of combustion may perhaps affect the efficiency of the optical apparatus, and the moving parts are at sea and beyond control. Nothing but a continuous trial for some length of time can determine which is the preferable. It is to be hoped that one or other may prove suitable, for the conveyance of electricity from the shore to outlying rocks promises to form a new and most important era in maritime illumination. The time, indeed, may not be far distant when such a navigation as the entrance to Liverpool will be as clearly defined at night as in the daytime, by the illumination of its beacons and buoys by electricity.

Mr. Siemens's apparatus was worked by twenty cells, while the induction-spark had only six, but when fully equipped, it will be worked by eighteen cells. Each apparatus was shown in the focus of a Holophote, the former producing the most powerful flash.

Mr. C. W. Siemens, F.R.S., of London, having been asked by Messrs. Stevenson for suggestions as to the best means to be adopted for carrying out Mr. T. Stevenson's proposal for producing a flashing light upon a beacon, by means of a land battery connected to the beacon through a submarine cable, embodied his views in a letter addressed by him to Messrs. Stevenson on the 1st October 1866. After reviewing the objections to other methods, he recommended the application of the extra-current together with a self-feeding mercury contact, as the only practical method in which the flash is not destroyed by electric charge of the connecting cable. Mr. Siemens having been authorized by the Northern Light Commissioners to construct an apparatus in accordance with his views, has submitted the same to a successful trial.

The apparatus upon the beacon or buoy consists of a heavy electromagnet, the coils of which are permanently connected with the conducting wire of the cable on the one hand, and with a contact lever on the other hand, which contact lever is actuated by the armature of the electromagnet in the manner of a nefts hammer. The circuit with the battery (consisting of from ten to twenty Bunsen's elements) on land is completed through the sea. When the current has had time to excite the electromagnet sufficiently for it to attract its heavy armature, the motion of the latter breaks the circuit, which breakage is accompanied with a spark proportionate to the accumulated magnetism, and in some measure also to the capacity of the cable, which in this apparatus does not destroy, but rather assists the effect. The luminous effect is increased by a slight combustion of mercury, which latter is continually renewed by a circulating pump worked by the armature, by which arrangement a good and permanent contact is ensured.

On a Self-acting Electrostatic Accumulator. By Sir W. Thomson, *LL.D., F.R.S.*

The apparatus described in a recent communication to the Royal Society, entitled "On a Self-acting Apparatus for multiplying and maintaining Electric Charges, with applications to illustrate the Voltaic Theory," was exhibited in action. Both Leyden jars being at first discharged as completely as could be done by keeping their outer and inner coatings connected for several days, they became charged, one positively and the other negatively, through the action of the drops of water, to such a degree, in the course of a few minutes, as to cause the jets of water to scatter over the lips of the receivers. The jars were afterwards repeatedly discharged, and the rapid reaccumulation of charges was shown to the Meeting by the scattering of the jets, by electroscopic tests, and by sparks drawn from the insulated conductors.

On a Series of Electrometers for Comparable Measurements through Great Range. By Sir W. Thomson, *LL.D., F.R.S.*

These instruments, which were referred to in Mr. Jenkin's Report of the Standards of Electrical Units Committee, were exhibited to the Section, and some of them shown in action. A description of them, with drawings, will appear in an appendix to that Report.

On a Uniform-Electric-Current Accumulator. By Sir W. Thomson, *LL.D., F.R.S.*

Conceive a closed circuit, CTABC, according to the following description:—One portion of it, TA, tangential to a circular disk of conducting material and somewhat longer than the radius; the continuation, AB, at right angles to this in the plane of the wheel, of a length equal to the radius; and the completion of the circuit by a fork, BC, extending to an axle bearing the wheel. If all of the wheel were cut away except a portion, CT, from the axle to the point of contact, at the circumference, the circuit would form a simple rectangle, CTAB, except the bifurcation of the side BC. Let a fixed magnet be placed so as to give lines of force perpendicular to the wheel, in the parts of it between C the centre and T the point of the circumference touched by the fixed conductor; and let power be applied to

cause the wheel to rotate in the direction towards A. According to Faraday's well-known discovery, a current is induced in the circuit in such a direction that the mutual electromagnetic action between it and the fixed magnet resists the motion of the wheel. Now the mutual electromagnetic force between the portions AB and CT of the circuit is repulsive, according to the well-known elementary law of Ampère, and therefore resists the actual motion of the wheel; hence if the magnet be removed there will still be electromagnetic induction tending to maintain the current. Let us suppose the velocity of the wheel to have been at first no greater than that practically attained in ordinary experiments with Barlow's electromagnetic disk. As the magnet is gradually withdrawn let the velocity be gradually increased, so as to keep the strength of the current constant, and, when the magnet is quite away, to maintain the current solely by electromagnetic induction between the fixed and moveable portions of the circuit. If, when the magnet is away, the wheel be forced to rotate faster than the limiting velocity of our previous supposition, the current will be augmented according to the law of compound interest, and would go on thus increasing without limit were it not that the resistance of the circuit would become greater in virtue of the elevation of temperature produced by the current. The velocity of rotation, which gives by induction an electromotive force exactly to that required to maintain the current, is clearly independent of the strength of the current. The mathematical determination of it becomes complicated by the necessity of taking into account the diffusion of the current through portions of the disk not in the straight line between C and T; but it is very simple and easy if we prevent this diffusion by cutting the wheel into an infinite number of infinitely thin spokes, a great number of which are to be simultaneously in contact with the fixed conductor at T. The linear velocity of the circumference of the wheel in the limiting case bears to the velocity which measures, in absolute measure, the resistance of the circuit, a ratio (determinable by the solution of the mathematical problem) which depends on the proportions of the rectangle CTAB, and is independent of its absolute dimensions.

Lastly, suppose the wheel to be kept rotating at any constant velocity, whether above or below the velocity determined by the preceding considerations; and suppose the current to be temporarily excited in any way, for instance, by bringing a magnet into the neighbourhood and then withdrawing it; the strength of this current will diminish towards zero or will increase towards infinity, according as the velocity is below or above the critical velocity. The diminution or augmentation would follow the compound interest law if the resistance in the circuit remained constant. The conclusion presents us with this wonderful result: that if we commence with absolutely no electric current, and give the wheel any velocity of rotation exceeding the critical velocity, the electric equilibrium is unstable: an infinitesimal current in either direction would augment until by heating the circuit, the electric resistance becomes increased to such an extent, that the electromotive force of induction just suffices to keep the current constant.

It will be difficult, perhaps impossible, to realize this result in practice, because of the great velocity required, and the difficulty of maintaining good frictional contact at the circumference, without enormous friction, and consequently frictional generation of heat.

The electromagnetic augmentation and maintenance of a current discovered by Siemens, and put in practice by him, with the aid of soft iron, and proved by Maxwell to be theoretically possible without soft iron, suggested the subject of this communication to the author, and led him to endeavour to arrive at a similar result with only a single circuit, and no making and breaking of contacts; and it is only these characteristics that constitute the peculiarity of the arrangement which he now describes.

On Volta-Convection by Flame. *By* Sir W. Thomson, *LL.D., F.R.S.*

In Nichols' Cyclopedia (2nd edition), article "Electricity, Atmospheric," and in the Proceedings of the Royal Society, May 1860 (Lecture on Atmospheric Electricity), the author had pointed out that the effect of the flame in an insulated lamp, is to reduce the lamp and other conducting material connected with it to the

same potential as that of the air in the neighbourhood of the flame; and that the effect of a fine jet of water from an insulated vessel, is to bring the vessel and other conducting material connected with it to the same potential as that of the air, at the point where the jet breaks into drops. In a recent communication to the Royal Society "On a Self-acting Apparatus for multiplying and maintaining Electric Charges, with applications to illustrate the Voltaic Theory," an experiment was described in which a water-dropping apparatus was employed to prove the difference of potential in the air, in the neighbourhood of bright metallic surfaces of zinc and copper, metallically connected with one another, which is to be expected from Volta's discovery of contact electricity. In the present communication a similar experiment was described, in which the flame of a spirit lamp was used instead of a jet of water breaking into drops.

A spirit lamp is placed on an insulated stand connected with a very delicate electrometer. Copper and zinc cylinders, in metallic connexion with the metal case of the electrometer, are alternately held vertically in such a position that the flame burns nearly in the centre of the cylinder, which is open at both ends. If the electrometer reading, with the copper cylinder surrounding the flame, is called zero, the reading observed with the zinc cylinder surrounding the flame indicates positive electrification of the insulated stand bearing the lamp.

It is to be remarked that the different methods here followed eliminate the ambiguity involved in what is meant by the potential of a conducting system composed partly of flame (alcohol) and partly of metal. In a merely illustrative experiment, which the author has already made, the amount of difference made by substituting the zinc cylinder for the copper cylinder round the flame, was rather more than half the difference of potential maintained by a single cell of Daniell's. Thus, when the sensibility of the quadrant divided-ring electrometer * was such that a single cell of Daniell's gave a deflection of 79 scale-divisions, the difference of the reading, when the zinc cylinder was substituted for the copper cylinder round the insulated lamp, was 39 scale-divisions. From other experiments on contact electricity made seven years ago by the author, and agreeing with results which have been published by Hankel, it appears that the difference of potentials in the air, in the neighbourhood of bright metallic surfaces of zinc and copper in metallic connexion with one another, is about three-quarters of that of a single cell of Daniell's. It is quite certain that the difference produced in the metal connected with the insulated lamp, would be exactly equal to the true contact difference of the metals, if the interior surfaces of the metal cylinders were perfectly metallic (free from oxidation or any other tarnishing, such as by sulphur, iodine, or any other body); provided the distance of the inner surface of the cylinder from the flame is everywhere sufficient to prevent conduction by heated air between them, and provided the length of the cylinder is infinite (or, practically, anything more than three or four times its diameter).

The author hopes before long to be able to publish a complete account of his old experiments on contact electricity, of which a slight notice appeared in the Proceedings of the Literary and Philosophical Society of Manchester.

On Electric Machines founded on Induction and Convection.
By Sir W. Thomson, *LL.D., F.R.S.*

To facilitate the application of an instrument for recording the signals of the Atlantic cable, recently patented by Sir W. Thomson, a small electric machine running easily enough to be driven by the wheelwork of an ordinary Morse instrument was desired; and he therefore designed a combination of the electrophorus principle, with the system of reciprocal induction described by him in a recent communication to the Royal Society (Proceedings, June 1867), which may be briefly described as follows:—

A wheel of vulcanite with a large number of pieces of metal (called carriers, for brevity) attached to its rim, is kept rotating rapidly round a fixed axis. The carriers are very lightly touched at opposite ends of a diameter by two fixed tangent springs. One of these springs (the earth-spring) is connected with the earth, and

* See Proceedings of Royal Society, June 20, 1867.

the other (the receiver-spring) with an insulated piece of metal called the receiver, which is analogous to the "prime conductor" of an ordinary electric machine. The point of contact of the earth-spring with the carriers is exposed to the influence of an electrified body (generally an insulated piece of metal) called the inductor. When this is negatively electrified, each carrier comes away from contact with the earth-spring, carrying positive electricity, which it gives up to the receiver-spring. The receiver and inductor are each hollowed out to a proper shape, and are properly placed to surround, each as nearly as may be, the point of contact of the corresponding spring.

The inductor, for the good working of the machine, should be kept electrified to a constant potential. This is effected by an adjunct called the replenisher, which may be applied to the main wheel, but which, for a large instrument, ought to be worked by a much smaller carrier-wheel, attached either to the same or to another turning shaft.

The replenisher consists chiefly of two properly shaped pieces of metal called inductors, which are fixed in the neighbourhood of a carrier-wheel, such as that described above, and four fixed springs touching the carriers at the ends of two diameters. Two of these springs (called receiver-springs) are connected respectively with the inductors; and the other two (called connecting springs) are insulated and connected with one another. They are so situated that they are touched by the carriers on emerging from the inductors, and shortly after the contacts with the receiver-springs. If any difference of potential between the inductors is given to begin with, the action of the carriers, as is easily seen, increases it according to the compound interest law as long as the insulation is perfect. Practically, in a few seconds after the machine is started running, bright flashes and sparks begin to fly about in various parts of the apparatus, even although the inductors and connectors have been kept for days as carefully discharged as possible. The only instrument yet made is a very small one (with carrier-wheel two inches in diameter) constructed for the Atlantic Telegraph application; but its action has been so startlingly successful that great effects may be expected from larger machines on the same plan.

When this instrument is used to replenish the charge of the inductor in the constant electric machine, described above, one of its inductors is connected with the earth and the other with the inductor to be replenished. When accurate constancy is desired, a gauge-electroscope is applied to break and make contact between the connector springs of the replenisher when the potential to be maintained rises above or falls below a certain limit.

Several useful applications of the replenisher for scientific observation were shown; among others, to keep up the charge in the Leyden jar for the divided-ring mirror-electrometer, especially when this instrument is used for recording atmospheric electricity. A small replenisher, attached to the instrument within the jar, is worked by a little milled head on the outside, a few turns of which suffice to replenish the loss of twenty-four hours.

METEOROLOGY.

Notice respecting a Haystack struck by Lightning. By Sir DAVID BREWSTER, *K.H., LL.D., F.R.S.*

The author gave an account of the production of a substance found at the bottom of a circular passage made by a lightning stroke in a stack of hay at Dun in Forfarshire in 1827. The specimen, which was produced from the silex in the hay, had a greenish tinge, and contained portions of burnt hay. It has been deposited in the Museum of St. Andrews.

Observations of the Rainfall at Arbroath. By ALEXANDER BROWN.

A Comparison of the Kew and Lisbon Magnetic Curves during the Disturbance of February 20–25, 1866. *By* Senhor CAPELLO. *Communicated by* Dr. BALFOUR STEWART, *F.R.S.*

During the 20th, 21st, 22nd, 23rd, 24th, and 25th of February 1866, large magnetic disturbances were recorded by the magnetographs at the Lisbon Observatory. The present communication, relative to these disturbances, offers some interest on account of the apparent variability of the forces which are in action during the same disturbance, and also the apparently variable relations between these forces at Lisbon and the same forces at Kew. In a former comparison certain laws were deduced, and it was interesting to know if they were confirmed.

On the Results of Observations of Atmospheric Electricity at Kew Observatory and at Windsor, Nova Scotia. By Dr. J. D. EVERETT.

The Kew observations included in this paper extended from June 1862 to May 1864 inclusive, and were taken with Sir William Thomson's self-recording apparatus; specimens of the photographic curves thus taken being exhibited at the Meeting. The Windsor observations taken by Dr. Everett with apparatus of a different kind, also invented by Sir William Thomson, but not self-recording, extended from October 1862 to August 1864. Monthly averages which had been taken showed that at Kew there had in every month been two maxima in the day, one of them between eight and ten A.M., and the other, which was more considerable, between eight and ten P.M. At Windsor, on the contrary, the electricity between eight and ten P.M. had in every month been weaker than either between eight and ten A.M. or between two and three P.M. The annual curve for Kew had its principal maximum in November, and another in February or March. At Windsor the principal maximum was in February or March, and the minima in June and November. The annual curves for the two places agreed pretty well from January to October, but were curved in opposite directions from October to January.

On the Meteor Shower of August 1867. *By* GEORGE FORBES. *Communicated by* Professor SWAN, *F.R.S.E.*

The author gave the results of certain observations made by him at St. Andrews on the meteor shower of August 1867. The nights following the 9th, 10th, and 11th of the month were very cloudy, and no observations could be made. Most of the observations were made on the evening of the 10th and morning of the 11th. But even on this night a faint haze for the most part covered the sky. The meteors were almost all of the same size as stars of the 3rd or 4th magnitude. They were, with few exceptions, white. They lasted in general only about half a second. They were very rapid in their flight. One could hardly distinguish any nucleus. The train was visible, after its formation, only for a very small fraction of a second; and breaks in their tracks of about 1° were frequently noticed. The lengths of their paths extended from 3° to 15°, though in some cases they were 30° in length. Attention was chiefly directed to discovering the points of radiation, and to noting the times of appearance.

The Radiant-Points.—It was soon seen that there were two distinct radiant-points; the one in the region of Casseiopeia, the other about Andromeda. By drawing on the spot the courses of the meteors among the stars, the points of radiation were marked on a map, and were found to lie as follows:—That in Casseiopeia had for its right ascension $2^h\ 43^m$, and for its north polar distance 29° 30′. The other was in the constellation Pisces, and its position was R.A. $= 0^h\ 46^m$, N.P.D. $= 67°$.

The numbers of Shooting-stars.—The numbers of those which came from the Casseiopeian and Piscian groups, and also of the unconformable meteors, were all separated, and are shown in the following Table.

Time of appearance.	From Casseiopeia.	From Pisces.	Unconformable.	Total numbers.
h m h m				
From 10 30 to 10 45	4	..	0	4
„ 10 45 „ 11 0	5	..	0	5
„ 11 30 „ 11 45	5	..	1	6
„ 11 45 „ 12 0	5	..	1	6
„ 12 0 „ 12 15	3	1	1	5
„ 12 15 „ 12 30	5	..	0	5
„ 12 30 „ 12 45	6	..	0	6
„ 12 45 „ 1 0	5	2	0	7
„ 1 15 „ 1 15	5	2	0	7
„ 1 15 „ 1 30	14	6	0	20
„ 1 30 „ 1 45	6	5	0	11
„ 1 45 „ 2 0	4	4	1	9
„ 2 15 „ 2 30	1	1	0	2
„ 2 30 „ 2 45	2	0	2	4
Total	70	21	6	97

The position of the observer was not such as to see at all well those coming from Pisces till $12^h\ 45^m$.

The night of August 11 and the morning of August 12 were cloudy, but the positions and directions of flight of about a dozen shooting-stars were determined, from which it appeared that the radiant-point was in Casseiopeia, but that it was not so distinctly marked as on the previous night, and seemed to lie nearer to γ Casseiopeiæ *.

On the Gales and Hurricanes of the Indian Ocean South of the Equator.
By Charles Meldrum, *M.A.*

The author stated that by means of the log-books of vessels visiting the harbour of Port Louis, the Meteorological Society of Mauritius, since its formation in 1851, had been collecting meteorological statistics of the Indian Ocean in the form of a journal showing the state of the winds, weather, and sea, on every day. The total number of days' observations tabulated in chronological order down to the 31st of December, 1865, is 170,000, and in some years the daily average is from 70 to 80 observations of twenty-four hours each. Since 1853 a considerable number of Synoptic Charts (upwards of 500) have been constructed, and it is proposed to publish a series of such charts, showing the state of the winds and weather over the Indian Ocean at noon on each day for a period of one year. In addition to these tabulated observations, a mass of information has been collected regarding the gales which have occurred in the Indian Ocean, many of which have been described in the Society's Transactions. As Secretary to the Society, the author had opportunities of studying these gales, and being now in this country he begged permission to communicate some of the results of his investigations.

The gales and hurricanes of the Indian Ocean South of the Equator may be thus classified :—1st, trade-wind gales, in which the wind veers little; 2nd, the extra-tropical gales, between the parallels of 30° and 45° S., in which the wind generally veers or shifts; and 3rd, the tropical hurricanes, in which the wind always veers or shifts.

1. The trade-wind gales occur in all seasons, but chiefly in the winter months of June, July, and August, when the S.W. monsoon prevails north of the equator, and the S.E. trade-wind acquires additional strength from the demand made upon it to supply the monsoon, the two winds being apparently one system under the

* A change in the position of the radiant point of the August shower on different nights has long been suspected. See Professor Twining's remarks in the American Journal of Science, 2nd series. vol. xxxii. p. 444, and vol. xxxvi. p. 305. It is to be regretted that the cloudy state of the weather at St. Andrews prevented the settlement of this question; but probably some other observer has been more fortunate.

influence of the earth's rotation and the high temperature which prevails in the northern hemisphere. At Mauritius these gales are characterised by a barometric pressure of 30·200 to 30·400 inches. The wind sets in at South to S.S.E., and seldom veers more than a point or two, the barometer at times oscillating during the height of the gale, which is sometimes attended with passing showers, but never with heavy rain, thunder, or lightning. Generally the gale commences in about 30° S., and advances towards the equator, like an extensive wave or billow, the barometer rising at each successive locality some time before the wind acquires much force. It is preceded by a heavy sea, which occasionally proves dangerous near the equator. It lasts from one to ten days, and blows in fitful gusts, which at Mauritius have usually a pressure of 1 to 10 lbs. on the square foot, and at times of 10 to 20 lbs. Owing to the frequency of these gales the mean daily maximum force of the wind at Mauritius is greater in winter than in summer.

2. The extra-tropical gales, between the parallels of 30° and 45° S., also occur in all seasons, but are most violent from May to August inclusive. These gales are generally characterised by the presence of two currents of air, the one from the southward, and the other from the northward, the two currents being variously situated with respect to each other. At times they exist side by side, as surface-winds, the one from the S.W., and the other from the N.E., each occupying a belt of 5° to 30° in longitude, stretching from the parallel of 30° S. as far south as the observations extend, viz. 45° S. In the narrow space between the two winds, light airs, calms, and a high cross sea, with heavy rain, thunder, and lightning, generally prevail, and there the barometer is lowest. The belt of southerly winds lies to the west of the belt of northerly winds, and the two travel laterally to the eastward, preserving their relative positions often for several days. The gale of the 13th to the 20th of January, 1861, as would be seen by inspecting a number of charts illustrative of it, was a good example, and many others might be adduced. The barometer stands higher, and the thermometer lower, in the southerly than in the northerly wind. On the western side of the former the barometer has been known to stand as high as 30·650 inches, while in the trough, or space between the two winds, it stood at 29·000 inches. Sometimes there are several alternate belts of southerly and northerly winds, as in gales which took place on the 27th and 28th of July, 1863.

In place of forming parallel belts, however, the two winds are often inclined, and sometimes directly opposed, to each other. Occasionally, too, only one of them appears, the other, if it exists at all, being either above the surface-wind, or away in the South Atlantic, to which the observations do not extend. This was the case from the 14th to the 20th of May, 1865, when a violent north-wester occurred in the space between the meridian of Greenwich and 32° E., and the parallels of 30° and 45° S.

But whatever may be the positions of the two currents of air, the gales invariably travel to the eastward, and many of them have been traced from the meridian of Greenwich to 65° E. Where they originate, and how far they travel, has not been determined. It does not appear that they are revolving gales, although whirlwinds may occasionally occur between the inner edges of the two winds; for in no instance has the wind been traced round an axis, or central area, as in the case of the tropical hurricanes. They take place with so much uniformity and regularity that their progress may be traced from day to day and hour to hour, and the manner of the veering or shifting of the wind, when there are two currents, be known beforehand, the shift being (often suddenly) from N.E. to S.W., or from N.W.rd to S.W.rd, and the veering from N.E. to North, N.W., West, &c., or with the sun. They last from one to seven days, and travel at the rate of four to twenty miles an hour. The wind usually sets in at N.E.rd and ends at S.W.rd, or S.E.rd. After the shift, or when the wind comes to the south of west, the barometer rises, and in a few hours the wind gradually abates. They succeed one another at short intervals and with considerable regularity, but vary in force. Even the ordinary changes of wind and weather in that part of the ocean seem to be more or less dependent upon the antagonistic currents of air to which reference has been made.

3. Many persons were at first little disposed to accept the 'Law of Storms' as laid down by Redfield, Reid, Thom, and Piddington, and there were points on which these writers themselves were not agreed. Even at the present day there

are shipmasters and others who put little faith in the theory of revolving storms. But a careful investigation of all the great storms which have occurred in the Indian Ocean, south of the equator, during the last eighteen years, has amply confirmed the truth of the theory in the main. On the other hand, some corrections and modifications are required.

These rotatory storms, which are confined to the months of November to May inclusive, originate between the parallels of 6° to 14° S., and travel to the W.S.W., and afterwards, but not always, to the southward and S.E.; the wind invariably moving round a central space (which is usually characterised by a calm) from left to right, or with the hands of a watch; while the storm, which has a diameter of 1 to 1500 miles, moves onwards at the rate of 1 to 20 miles, but more frequently 4 to 7 miles an hour, for a period varying from a few hours to ten days, attended with torrents of rain, and in its northern half often with lightning.

It would appear that when they were first made a subject of investigation, attention was chiefly directed to what took place within the storm, all the information regarding it having been derived from a few vessels which had been involved in it; while little notice was taken of the state of the prevailing winds at a distance, or of the possible connexion between them and the origin and progress of the storm. Hence some writers appear to have regarded them as detached disks of air, put and sustained in motion by electricity, magnetism, earthquakes, or some other mysterious agency.

One of the first results of the extended system of observation adopted at Mauritius was to show, what had been surmised by Dr. Thom, that these revolving storms are invariably generated between the N.W. monsoon and the S.E. trade-wind, and that to all appearance their rise and progress are intimately connected with those two opposing winds. The fact that they occur only during the monsoon months in itself favours the supposition of a connexion between the two phenomena.

Observation has shown that the monsoon extends farther south on the western than on the eastern side of the Ocean, its southern limits often stretching obliquely from Tamatave, in Madagascar, on the west, to Sumatra on the east. To the south of the N.W. monsoon the S.E. trade-wind prevails. Between the two winds there is a space of calms, or light variables. During hot sultry weather evaporation must take place rapidly, especially in the trade-wind region. The vapour is carried by the two winds towards the space which separates them, and is accumulated there until the air becomes saturated. There may at the same time be an ascending column of air and vapour, which would further promote condensation. Heavy rain sets in, the barometer falls, and the two oppositely directed winds flow towards the locality of diminished pressure, bringing with them more vapour, which is also speedily converted into rain, the barometer falling lower.

As the vapour is chiefly supplied by the S.E. trade-wind, and its precipitation in the trade-wind region is followed by a decrease of barometric pressure there, the movement of the area of diminished pressure is towards the south, across the trade-wind region, the N.W. monsoon, and the N.E. trade-wind to the north of it, where the barometer is high, pressing to the southward to restore the equilibrium, and the monsoon, as it were, eating into the trade-wind as the aqueous precipitation proceeds. In this way the monsoon sometimes advances along its whole extent in longitude to the tropic of Capricorn, or even beyond it, until the trade-wind altogether disappears, or is found only far to the south. When the vapour has been precipitated the trade-wind gradually returns, the monsoon receding before it to the northward, until the two winds again attain their normal positions. After a lapse of some time, during which another accumulation of vapour takes place, heavy rains again commence on the equatorial borders of the trade-wind, and the monsoon again advances to the southward. The two winds thus oscillate backwards and forwards during the summer months, and it is on these occasions, when the monsoon is advancing to the southward, that the tropical revolving storms occur, the south-west and west sides of the storm being apparently fed by the trade-wind, and its north-east and east sides by the monsoon.

Instances of the advancement of the monsoon to the southward, as from the 13th to the 18th of February, 1860, the 16th to the 20th of January, 1861, the 1st to the 18th of February, 1861, and the 16th to the 24th of February, 1865, were given in a series of charts showing the directions of the wind at noon on each day.

Revolving storms, however, do not always take place on such occasions, although, as the monsoon approaches, the wind generally veers from E.S.E. to East, North, and N.W., with much rain, and generally thunder and lightning. Nor does the monsoon always advance along its whole extent in longitude, but more frequently penetrates into the trade-wind, and then only one rotatory storm is formed. When the monsoon and trade-wind are in collision over a considerable extent of longitude, or across the whole ocean, two or more revolving storms may be formed, which sometimes rage together for several days, as in the case of two violent hurricanes which occurred between the 8th and the 17th of February, 1861, and of several others between the 6th and 24th of April, 1866. On occasions like these as many as five rotatory storms have been known to exist at the same time along the inner borders of the two winds, but they did not all last long.

In the earlier and latter parts of the season these storms often do not travel beyond the parallel of 16° S. They are most frequent in February and March, and during those months they generally advance to 25° S., and sometimes to 30° or 32° S. Their tracks are generally curves, the convexities of which are towards the west, and the apices anywhere between the parallels of 14° and 24° S., according to the season. It would appear that they traverse the trade-wind region in consequence of the progress of the aqueous precipitation being in that direction, and of the monsoon extending farther south on the western than on the eastern side of the ocean, as already stated. The direction of the wind in the body of the storm may be accounted for by the relative positions and directions of the monsoon and trade-wind, independently of the earth's rotation on its axis, although that also may have an effect.

With regard to the form of these storms, it varies, and is not so circular as is usually supposed. The wind generally blows spirally towards and ultimately around the centre, as is shown, not only by the collective evidence of vessels on all sides of the storm, but also by individual vessels occasionally running completely round the centre, and being gradually drawn into it. An example of this occurred in May, 1863, when a vessel belonging to the port of Dundee, called the 'Earl of Dalhousie' (Capt. Campbell), scudded, at the rate of 10 to 13 knots an hour, three times round the centre of a revolving storm, which at the time happened to be nearly stationary, till at length she reached the central calm. (Charts were exhibited showing the positions of the vessels and directions of the wind in this storm at noon on each day from the 7th to the 20th of the month.)

As the trade-wind in front of a revolving storm often blows in strong gales with a falling barometer over many degrees in longitude, and the direction of the wind, especially at a distance, is far from being at right angles to the bearing of the centre, severe losses have occurred in consequence of vessels, having the wind at S.E., running to the west or N.W. with the view of crossing the storm's path, under the impression that the centre bore N.E. In place of bearing N.E., when the wind is from S.E., the centre may bear North or N.N.W., and if the storm be travelling to the S.W., as is often the case, a vessel steering westward or N.W. may be running to her destruction. During a hurricane in February, 1860, for example, a number of vessels left the roadsteads of Reunion with the wind at S.E., and, running to the N.W., got into the heart of the storm. Several of them were wrecked on the coast of Madagascar, others were never heard of, and of those that returned some had to be abandoned. The safest course seems to be to lie to and watch the barometer and wind till the bearing of the centre be known with some certainty.

But perhaps the greatest losses of life and property in the Indian Ocean south of the Equator arise from homeward-bound vessels running into revolving storms to the southward of them, by taking supposed advantage of the N.E. winds of a storm, between the parallels of 10° and 16° S., and steering to the S.W. till they get in front of the storm. This is the more to be regretted, inasmuch as all such losses may be easily avoided by lying-to till the barometer rises and the weather improves, or by proceeding cautiously to the southward. Heavy losses occur annually from inattention to this simple precaution. In May, 1863, for instance, of twelve homeward-bound vessels which had got involved in a revolving storm by running to the southward with increasing winds, falling barometer, and threatening weather, two had to be abandoned at sea, and the others were so disabled that on arriving at

Port Louis some of them were condemned, and some detained for two or three months undergoing repairs. The loss on that single occasion must have amounted to at least £60,000, and there is not the slightest doubt that it would have been avoided if the vessels had kept back for a day or two, and not run headlong into the storm. In the hurricane season, in those latitudes, with the wind anywhere between north and south, through the west, the weather squally and threatening, and the barometer falling, a vessel should not press too much to the southward. By attention to this rule the storm will be avoided.

Experience has proved that the existence of a gale belonging to any one of the three classes above described is indicated at Mauritius by the barometer, winds, and weather, even when the distance is very considerable. A trade-wind gale is preceded by a high and rising barometer, and by the setting in of the wind at southward, generally with a clear sky. On the other hand, the barometer at Mauritius always falls during a gale belonging to either of the other two classes. As a general rule, if the barometer fall steadily for three or four days to the extent of even one-tenth of an inch below its height for the season, it may be inferred either that a tropical gale exists on the equatorial borders of the trade-wind, or an extra-tropical one on its polar borders; and the direction and veering of the wind, and the character of the clouds, will determine in which of these directions the disturbance is taking place. At the setting in of a tropical gale away to the northward or N.E., the trade-wind at Mauritius is drawn towards the locality of diminished pressure, and the barometer falls. When an extra-tropical gale takes place away to the S.W., towards the Cape of Good Hope, the trade-wind is deflected in that direction, so as to form a part of the N.E. winds of the east side of the gale, and in this case also the barometer falls at Mauritius, until the southerly winds of the west side of the gale have begun to exert their influence, as the gale advances to the eastward. The existence of all the heavy gales which have taken place in either direction, for some years back, has been known at Mauritius, and frequently announced in the newspapers at the time.

On Meteorological Observations at Sea. By F. W. Moffat. *Communicated by* Dr. Moffat.

These observations were made for the purpose of ascertaining the quantity of ozone in different degrees of latitude and longitude at sea. The observations extend between lat. 53° N. and 39° S., and long. 83° E. and 25° W. The author had observed that as the wind veered with increasing readings of the barometer from south points of the compass through west to north, ozone disappeared, and continued absent while the wind was in points between north and east, and that it reappeared as the wind veered with decreasing readings of the barometer to south points. The disappearance and reappearance of ozone with these conditions were so regular that the changes appeared to be the result of an invariable atmospheric law, and the author was induced to examine the law of the rotation of the wind, so clearly developed by Dove, and the results of the examination led him to believe that the polar current is the non-ozoniferous, or that of minimum of ozone, and that the equatorial, or sea-wind, is the ozoniferous, or that of the maximum of ozone. According to the rotation theory, the polar current in the northern hemisphere forms the N.E "trade," and that in the southern hemisphere forms the S.E. "trade," while the equatorials in the northern and southern hemispheres form the upper or returning "trades." These returning "trades" come to the earth's surface in both hemispheres about the 28th degree (the latitude varies with the season), north and south of the equator. The author stated that if his deductions are trustworthy, the N.E. and S.E. "trades" ought to be the minimum of ozone currents, and the returning "trades" the maximum of ozone currents; that in the northern hemisphere forming the S.W. wind, and the other in the southern hemisphere a N.W. wind; and as these currents consisted of the atmospheres of equatorial latitudes, the quantity of ozone ought to be at least as great at the equator as with the returning currents. The author showed by tabulated results that such was the case, and he expressed a belief that were it not for the modifying effects of the trade-winds, ozone would be a constant quantity at sea.

On the Errors of Aneroids at various Pressures.

By BALFOUR STEWART, *LL.D., F.R.S., Superintendent of Kew Observatory.*

At the request of the Meteorological Committee experiments have lately been made at Kew Observatory, with the view of ascertaining to what extent an aneroid may be considered as a reliable instrument when exposed to considerable changes of pressure, such as occur in mountain ascents.

In order to make these experiments, a large receiver had attached to it a standard barometer, of which the accuracy had been previously ascertained. By means of an air-pump, the aneroids, when placed in this receiver, might be subjected to any pressure, the exact amount of pressure being noted by the standard barometer. An arrangement devised by Mr. Beckley, mechanical assistant at Kew, enabled the aneroids to be tapped while in the receiver, so as to imitate, as well as possible, the tapping of the hand, to which these instruments are usually subjected previous to their readings being taken.

For the aneroids, to which I shall immediately refer, observations were made for every inch of pressure between 30 inches and 19 inches, ten minutes being occupied in going from one stage to the next, and the instruments being always tapped at every stage. When they had reached their lowest pressure, they were kept at this for an hour and a half, and were then raised in stages of 1 inch every ten minutes until the ordinary atmospheric pressure was finally reached. The instruments themselves were obtained from the best-known makers, who kindly lent aneroids for the purpose of this experiment.

The following Table denotes the average behaviour of these instruments so treated, eight sets of experiments having been made, and the instruments being one half large instruments, diameter 4 inches, and one half small instruments, diameter 2 inches.

Supposing the instruments were quite right at starting at the pressure of 30 inches, then their behaviour while the pressure was being lowered is represented by the following Table:—

	in.		in.
At 30 inches, error	·00	At 24 inches, error	−·02
„ 29 „ „	+·03	„ 23 „ „	−·05
„ 28 „ „	+·03	„ 22 „ „	−·08
„ 27 „ „	+·01	„ 21 „ „	−·12
„ 26 „ „	·00	„ 20 „ „	−·18
„ 25 „ „	−·02	„ 19 „ „	−·22

From this Table we may learn the following facts:—

1. If we compare an aneroid with a standard barometer before beginning our observations, in order to ascertain its index error, and if we then gradually lower the pressure, using the above index error, we shall find that the instrument lags behind or reads rather too high down to 26 inches, at which point its behaviour appears to be reversed, and it falls thereafter too fast.

2. The instrument is, however, tolerably accurate down to 24 inches, or through a range of 6 inches.

3. If we compare the aneroid with a standard at the end instead of at the beginning of the observations, we shall get much less reliable results.

Suppose now that the instrument is allowed to remain an hour and a half at the lowest pressure, and that it starts from this pressure of 19 inches, going upwards, being quite right at starting, as compared with a standard barometer, then the average behaviour will be represented by the following Table:—

	in.		in.
At 19 inches, error	·00	At 25 inches, error	+·01
„ 20 „ „	−·02	„ 26 „ „	+·03
„ 21 „ „	−·02	„ 27 „ „	+·05
„ 22 „ „	−·02	„ 28 „ „	+·08
„ 23 „ „	−·01	„ 29 „ „	+·12
„ 24 „ „	·00	„ 30 „ „	+·14

From Table II. we may learn as follows:—

1. If we start from a low pressure (19 inches) and compare our aneroid with a

standard barometer before beginning our observations in order to ascertain its index error, and if we then gradually increase the pressure, using the above index error, we shall find that the instrument lags behind, that is to say, reads too low up to 24 inches, at which point its behaviour appears to be reversed, and it thereafter rises too fast.

2. The instrument is, however, tolerably accurate up to 25 inches, or through a range of 6 inches.

3. If we compare our aneroid with a standard at the end instead of the beginning of the observations, we shall get much less reliable results.

So much for the double experiment, in which the pressure is first lowered and then raised.

Now, if at the end of this experiment we compare our aneroid with a standard once more at the ordinary pressure, we shall find that, on the whole, its indications have fallen, or it reads too low, but gradually, and in course of time, it recovers itself.

This is seen by the following instances:—

2-inch aneroid.

Error before experiment		+·47
Immediately after	„	+·19
23 hours after	„	+·34
40 „	„	+·37

$2\frac{3}{4}$-inch aneroid.

Error before experiment		+·11
Immediately after	„	+·03
18 hours after	„	+·10

$4\frac{1}{2}$-inch aneroid.

Error before experiment		+·04
Immediately after	„	−·06
1 hour after	„	−·05
18 hours after	„	−·01
3 days after	„	+·01
3 weeks after	„	+·07

In the next place, I would remark that large aneroids are better than small ones, as will be seen by the following Table denoting the average behaviour of small and large instruments for the down observation.

Pressure	Error of large.	Error of small.
30	·00	·00
29	+·04	+·04
28	+·04	+·02
27	+·02	·00
26	+·01	—·02
25	·00	−·06
24	−·02	—·07
23	—·04	—·11

The experiments are not yet quite finished, but we may perhaps conclude—

1. That if a good 4-inch aneroid be first of all compared with a standard barometer, and then gradually subjected to a decrease of pressure, it will give reliable results through a range of 6 inches.

2. That if a good 4-inch aneroid be first compared with a standard barometer at a low pressure, and then gradually subjected to an increase of pressure, it will give reliable results through a range of 6 inches, starting from the low pressure.

3. The results would probably be still better if the instrument, before use, were compared with a standard barometer after the manner I have now described.

Storm-Warnings, their Importance and Practicability. *By* Colonel Sykes, *M.P., F.R.S.*

The author adduced the testimony of numerous men of scientific eminence, and the Reports from the seaports to the great importance of the signals lately in practice at the Meteorological Department of the Board of Trade, both from humane and commercial points of view, and then stated that out of 405 warnings given in three years, the prognostications were correct for 305 times. No one could tell the possible number of lives and amount of property which had thus been saved; and he asked if this did not sufficiently justify the continuance of these storm-warn-

ings, even though founded on supposed empirical data. The Scientific Committee of the Royal Society had declined to continue these warnings, on the ground that Admiral FitzRoy had obtained his conclusions on empirical data. The author stated that the Committee proposed to establish eight additional observatories throughout the empire; and at the end of fifteen years they expected to be able to predict storms on philosophical data, and not on empirical data. But if during the last fifty years all the Observatories of the kingdom had not been able to obtain these results, the author thought that they were not likely to do so during the next fifteen years, and the cost of maintaining them would be wasted.

On Evaporation from Rain-gauges. By JOHN THRUSTON.

CHEMISTRY.

Address by the President, THOMAS ANDERSON, *M.D., F.R.S.E.*

ON many previous occasions the British Association has met in places which have afforded the chemist valuable opportunities of seeing the principles of his science reduced to practice, and the various papers which have been read at this Section on these subjects, and the discussions which have arisen regarding them, have formed a very interesting department of its proceedings. At the present Meeting little of this is likely to engage our attention; for though the manufactures of Dundee have probably increased, during the last ten or fifteen years, in a more rapid ratio than those of any other town in the kingdom, they have taken a direction which gives but little scope for the applications of chemistry, so that with the exception of a few of the simpler operations of the dyer, there is really scarcely anything which need specially attract our attention. Under these circumstances it may be fairly anticipated that the business of the Section will be more particularly occupied with the discussion of the great principles of the science which to the general public are often less interesting, and regarded as the exclusive province of those engaged in scientific study, and not sufficiently recognized as being the only sure foundation on which the superstructure of practical progress can be raised.

The consideration of these general principles is, however, at the present moment a matter of the very highest importance, for the science of chemistry is in a state of transition. The immense accumulation of facts which has been made during the last twenty or thirty years, has not only increased her bounds, but has shown the insufficiency of those principles on which the chemist was formerly ready to rely with almost implicit confidence, and introduced changes amounting to a revolution, which have had the effect of unsettling the views formerly entertained, without as yet introducing anything which can be considered satisfactory in their place. The atomic theory, which at the commencement of the present century explained with clearness and precision all the facts of the science then known, has proved itself (at least in the form in which Dalton left it) no longer sufficient for the purpose. At the time at which it was produced, the knowledge of chemists was confined to a comparatively small number of compounds, among which those of oxygen had so preponderating an importance that the science of the time might almost be described as the chemistry of oxygen. At the present moment, if we were to attach to it the name of any individual element, we should probably describe the whole science by the definition which has been so often applied to organic chemistry, and call it the chemistry of carbon, for it is in the study of the compounds of that element that all the difficulties with which the chemist has now to contend have had their origin. At a comparatively early period indeed, doubts were expressed as to the sufficiency of the atomic theory of Dalton, and Ampère especially suggested that the chemical atom might with advantage be considered to be a congeries of smaller particles; but this and other analogous additions to the original conceptions of the chemical atom, being of a purely speculative character, and having no immediate bearing on the facts then, or even now known, have never been accepted by chemists, or received from them more than a

very passing notice, and were not unfairly considered to be unnecessary complications of the theory. It was left for time to accumulate facts, for which Dalton's theory supplied no explanation of any kind, and these were at first neglected; but as their number increased, their explanation was evaded by the invention of names intended to group together facts supposed to be dependent on similar causes. Such names as catalysis, allotropy, and the like, really explain nothing; they are little better than scientific lumber-rooms, in which unexplained facts are stowed away until it suits our knowledge or our convenience to classify and explain them. I am far from asserting that this mode of grouping facts supposed to have something in common, has not its advantages, provided only it be distinctly understood that it is the grouping of ignorance. The risk lies in the name being accepted as an explanation, and inquiry being thereby retarded—and something of this sort has indeed occurred; for though these facts were admitted to be beyond the scope of the atomic theory, they were quietly set aside; things went on as they were before, and it was not till the introduction of the theory of atomicity, which shows itself in every chemical fact, that the doubts which had been long gathering in the minds of all thoughtful chemists, found distinct expression. I do not on the present occasion propose to discuss in detail the effect which the introduction of this view has had upon chemical theory, further than to remark that it renders it necessary either to abandon altogether the atomic theory of Dalton, or to introduce into it such modifications as fundamentally alter its entire character, and make it substantially a new theory. The former is an alternative which some chemists will be greatly disinclined to adopt. They will not willingly abandon a theory which has admittedly done admirable service, which at its first introduction established order and regularity where confusion and disorder previously reigned supreme, and under whose influence the science has attained its present goodly proportions. Others again may be of opinion that the atomic theory has done its work, and in the future is less likely to act as an assistance than as a hindrance to progress, by forcing us to consider all facts in its particular light, and causing us to overlook relations which might be at once detected by an unbiassed mind.

This latter opinion has been very strongly expressed by Sir Benjamin Brodie, and in the Calculus of Chemical Operations, which he has recently made public, we have the first systematic attempt which has been made to express the constitution of chemical compounds by a method in which the idea of an atom has no place. As this is the most important chemical doctrine which has been put forward for many years, and must, if accepted, materially alter our present views, I shall venture to consider it in some detail, premising, however, that as only the first part of the investigation has yet been made public, any opinion I may now express regarding it may be liable to modification when the entire investigation is published.

Sir B. Brodie, as has been already observed, discards altogether the idea of an atom, and compares with one another the weights of different substances in the gaseous state which are capable at the standard temperature and pressure of filling a unit of space, which is the bulk of 1000 cubic centimetres. If we consider this space to be empty, and fill it with hydrogen, a chemical operation is performed which is represented by the symbol α, expressing the fact that the weight so introduced is chemically indivisible. If now in place of hydrogen oxygen be introduced, the unit of space is filled by a quantity sixteen times as great, but this weight is not indivisible, as is at once apparent if we notice what happens when oxygen is introduced into the unit of space already filled with hydrogen. In that case a second operation is performed on it, in which a weight eight times as great as that of the hydrogen is introduced, and water is the result. The quantity of oxygen which fills the unit of space must therefore be regarded as divisible, and this is expressed by assigning to it the symbol ξ_2, indicating the fact that two identical operations are required to fill the unit of space with oxygen. By the same line of argument it is concluded that sulphur, selenium, &c., must be similarly constituted, and they are accordingly represented respectively by θ_2, λ_2, &c. So far it will be observed that the system is merely a modification of that at present used by chemists for expressing the laws of gaseous combination, excepting that all substances, compounds as well as elements, are referred to the unit of space, while, according

to our present plan, the former are referred to two units of space and the latter to one. But when the compounds of chlorine and the allied elements, with hydrogen, are to be represented according to Sir B. Brodie's system, it at once becomes apparent that some further hypothesis must be introduced if they are to be referred to the same volume. When the quantity of hydrogen represented by the symbol α, unites with chlorine, the product fills two units of space, and as, according to the fundamental hypothesis, α is indivisible, the question is to obtain some means of expressing without fractions the quantity of hydrochloric acid which fills the unit of space. This end Sir Benjamin attains by assuming that chlorine is itself a compound of hydrogen with an unknown element to which the symbol χ is assigned; chlorine being $\alpha\chi_2$, and formed by three operations, one being hydrogen, and the other two which are identical, result in the introduction into the unit of space of two quantities of a hypothetical substance χ, whose weight is 17·25; and according to this view, when hydrogen and chlorine unite, the action is expressed by the equation

$$\alpha\chi_2+\alpha=2\alpha\chi.$$

On precisely the same principle iodine, bromine, nitrogen, phosphorus, antimony, and bismuth must also be hydrogen compounds. It is obvious therefore that Sir Benjamin's system involves a very large amount of hypothesis; for it assumes that a considerable number of those substances hitherto regarded as elements are really compounds. I do not imagine that much difficulty will be experienced by any one in admitting the possibility of this, for I apprehend there is no chemist who imagines those bodies which we call elements to be the ultimate constituents of matter, or who doubts that the time, though still far distant, will come when they may be resolved into simpler substances. But when we come to reduce these speculations to a definite form, and seek to make them part of the science itself, it becomes essential to subject them to a very close and searching scrutiny.

In order to justify their assumption, it seems to me necessary either that they should be supported by experimental evidence, or that they should afford the means of tracing out unsuspected relations, and thus extending the bounds of the science, or, at all events, that they should involve the minimum amount of hypothesis. Now, as regards the first of these, it is unnecessary to observe that there is not one tittle of evidence to show that chlorine is a compound any more than hydrogen itself. As far as extending the bounds of the science is concerned, we must look for an answer to the future, and it may be expected that in the remaining parts of the investigation, which it is to be hoped may soon be made public, it will be shown how the method may be used for this purpose; but, in the meantime, I am unable to see how it is to open up new fields of inquiry, and it is certain that it leaves unexplained all those anomalies which are usually considered to be the weak points of the existing system. Neither can it be asserted that the system involves the minimum amount of hypothesis; for, in point of fact, the assumption of the compound nature of certain of the elements is rendered necessary by the fundamental hypothesis that α is indivisible. If it be assumed to be divisible, the necessity for holding those elements to be compound at once falls to the ground, and I confess it appears to me that we should require very clear evidence of the advantages it offers before we accept a hypothesis involving so many others. The question must at best be considered as still *sub judice*, and the method is not likely to meet with general acceptance until it is supported by a much larger body of facts than those we at present have.

While Sir B. Brodie's theory is one from which the idea of atoms is excluded, it is important to notice that it is by no means incompatible with them, and it even appears to me that though it may suit our convenience to consider matter in relation to space only, the real subject of inquiry is not the unit of space, but the unit of matter, and to it we must eventually come. If I hold, as I most undoubtedly do, that the atomic theory of Dalton must sooner or later be abandoned, it is not because I do not believe in the existence of a unit of matter. Whether we assume it to be a hard spherical particle, a centre of force, or a vortex produced in a perfect ether, is another question; but it seems evident that some kind of molecular hypothesis is indispensable for the explanation of physical phenomena, and it is scarcely possible to doubt that some connexion must exist between the chemical

and the physical unit of matter. In the mean time it is only by the most cumbrous and improbable assumptions that the existing atomic theory can be made to fit in with the facts which chemistry has recently discovered, and of these the theory of atomicity is one which can scarcely be connected with it at all. In point of fact that theory is a merely temporary hypothesis, constructed to keep before our eyes the tendency which substances have to form compounds of certain definite forms, under special circumstances; and it is scarcely possible to doubt, that in twenty or thirty years it will have passed away and have been replaced by something of a more satisfactory character. Meanwhile its important influence on the recent progress of chemistry is too obvious to be disputed. It is only to be regretted that so many conflicting modes of considering the atomicities of the elements should have been introduced by different writers.

Into the consideration of this matter I should have been glad to have entered at some length, but I feel that I have already detained you too long from the actual business of the Section, and no doubt opportunities will arise in the course of the business for individuals expressing their opinions on this and other subjects. Among these the mode of expressing the symbols of chemical compounds, which was objected to long since by Sir John Herschel, and has been again brought into prominence by the publication of Sir B. Brodie's paper, merits attention. The present unsettled state of chemical nomenclature, so inconvenient to the teacher, ought also to be discussed, and it might even be well to consider whether a committee should not be appointed to ascertain how far it might be possible to adopt a uniform system. Nor do I think we ought to separate without recording our opinion on the subject of better and more extended scientific education. The events of the Paris Exhibition have brought our deficiencies in this respect very conspicuously before us, and show us how much we have yet to do. That we have made progress in this respect is not to be doubted, for science is much more cultivated now than formerly, and is becoming more and more a branch of general education. Much, however, still remains to be done in this direction, especially in Scotland, and it will no doubt surprise many of my audience to hear that chemistry and natural history are still excluded from the course of study for degrees in arts in the Scotch universities. Of late years the study of these and other departments of natural science has been introduced to some extent in schools both in England and Scotland; but, so far as my experience goes, without having as yet produced results of much importance. The difficulty, I think, lies in the kind of instruction offered; the usual practice having been to give lectures from which the discussion of principles and of everything which exercises and developes the mind, is eliminated, and only that which it is supposed will entertain or surprise is retained, and boys are thus led to look upon science merely as a pastime. They are shrewd enough to see the difference between this and the closer and more severe system of study pursued in the other departments of their education, and they are apt either to avoid work altogether, or to acquire their knowledge in a superficial manner. The whole system of teaching science to school-boys is a subject which merits far more attention than it has yet received, and the success of the movement must greatly depend on an efficient method of teaching being adopted. All these, however, are subjects the discussion of which would carry me far beyond the limits of those introductory observations with which it has been customary to open the business of the Section. It must be left for its members to bring forward their own views on these and kindred questions.

On an Apparatus for indicating the Pressure and Amount of Firedamp in Mines. By G. Ansell.

On a Method of Recovering Sulphur and Oxide of Manganese used at Dieuze, near Nancy, France. By I. Lowthian Bell.

Remarks on the Calculus of Chemical Operations. By Dr. A. Crum Brown.

After observing that, as we have only the first part of Sir Benjamin Brodie's paper before us, it is necessary to be cautious in our criticism, the author enume-

rated his objections to the system. 1st. That the assumption of the distributive law of multiplication is unnecessary, and leads moreover to the anomalous result that the same direct operation does not always produce equal results when performed on the two sides of an equation, thus $x+y=xy$; but multiplying both sides by x we get x^2+xy and x^2y, which are not equal. 2nd. That the assumption (for which no evidence is produced) that the unit of hydrogen is a simple weight, leads to inconvenient formulæ, the symbol a being used to express not only the quantity of hydrogen in a substance, but also what those chemists, who use atomic language, would call the number of perissad atoms. 3rd. That a system of notation substantially the same in *form* as that at present in use might be deduced from Sir Benjamin Brodie's principles, upon the more reasonable convention that bodies hitherto undecomposed are not to be represented as compound. The ordinary chemical symbols might therefore be used in a functional as well as in an atomic sense.

A Note on Messrs. Wanklyn, Chapman, and Smith's method of determining Nitrogenous Organic Matters in Water. By Dugald Campbell, *F.C.S.*

At the meeting of the Chemical Society on June 20, Messrs. Wanklyn, Chapman, and Smith proposed to determine the nature and amount of the nitrogenous organic matters contained in drinking waters by the amount of ammonia given off when a given quantity of the water was distilled rapidly with the addition of certain weights of different reagents added at different parts of the distillation, the reagents being carbonate of soda, caustic potash, and permanganate of potash. Their experiments lead to the conclusion that when a litre of water is distilled with two grammes of carbonate of soda, *all* the nitrogen of the urea existing in the water will practically be found as ammonia in the first 300 c. c. distilled over, and that *none* of the nitrogen existing in albumen or "albuminoid" matters, which may be in the water, would be evolved as ammonia.

Experiments were made with pure distilled water containing respectively $\frac{1}{20}$, $\frac{1}{40}$, $\frac{1}{80}$, and $\frac{1}{100}$ parts of a grain of urea in a gallon, and in every case nitrogen remained in the water after distillation with the carbonate of soda, and was evolved by other means and estimated; and it was only when the $\frac{1}{120}$ part of a grain of urea, or less, was dissolved in a gallon of water that the urea was entirely decomposed by carbonate of soda and evolved as ammonia.

Experiments were likewise made with white of new-laid egg equal to $\frac{1}{20}$, $\frac{1}{40}$, $\frac{1}{80}$, and $\frac{1}{160}$ part of a grain of dry albumen dissolved in a gallon of pure distilled water, distilling one litre of each solution with two grammes of carbonate of soda; in every case distinct quantities of ammonia were evolved and estimated, and in the last experiment, with white of egg equal to the $\frac{1}{160}$ part of a grain of dry albumen per gallon, practically, all the ammonia in the albumen was evolved, there being a loss of only 0 000017 grain, a quantity so small as to be attributable to an error in observation or otherwise.

In all the experiments the ammonia was estimated by Nessler's test.

On the Synthesis of Formic Acid. By A. R. Catton.

On Loewig's Researches on the Action of Sodium Amalgam on Oxalic Ether. By A. R. Catton.

On a New Polarizing Photometer. By W. Crookes, *F.R.S.*

On a Self-Registering Perpetual Aspirator. By A. E. Fletcher, *F.C.S.*

This instrument was contrived to assist in carrying out the Alkali Act of 1863, in cases where a continuous register is required of the acidity of the air which passes along a flue or chimney. It is a continuous and self-acting aspirator, which draws a measured quantity of air from the flue or chimney through absorption-bottles, and registers the amount so drawn.

It consists, first, of a small fan three inches in diameter. This is placed in an

opening made in the side of the flue or chimney. The draught of air entering by this hole gives revolution to the fan, and thence, by means of an endless screw and toothed wheel, to a crank which moves a bellows-pump. This draws air from the flue or chimney by means of a tube inserted through the brickwork, and causes it to pass through the absorption-bottles. The whole is portable, being enclosed in a small box, except only the fan, which projects about three inches.

On an Ether Anemometer for Measuring the Speed of Air in Flues and Chimneys. By A. E. FLETCHER, *F.C.S.*

This instrument is contrived for measuring the speed of air in pipes, flues or chimneys in cases where, from the presence of heat, soot, or corrosive vapour, a delicate mechanism would be inadmissible. It has been called an ether-anemometer, since ether is employed in its construction; by it the speed of air moving at any greater rate than that of nine inches per second can be measured.

The principle employed in its construction is in part that of the Gifford's injector, wherein a current of steam passing the open end of a tube is made to produce a partial vacuum in it.

In the current of air whose velocity is to be measured, is placed a glass or metal tube with a plain straight end, and along with it a tube whose end is bent at right angles and cut off short. This bent end is turned to face the current, while the straight tube is so exposed to the current that it passes along its open end. The difference of pressure in these two tubes will then be a measure of the velocity of the current. The pull or suction of the chimney will be the same in each.

To measure this difference of pressure, which for slow currents is very small, many methods were tried until the present form of apparatus was adopted. It is but a modification of the U-tube; the limbs are cylinders of three inches in diameter and four inches in length, connected at the bottom by a small horizontal tube. The liquid used is ether, on account of its low specific gravity and its mobility. In each limb is a hollow metal float, scribed with a fine line. The level of these lines is read off by a finely divided scale and vernier adjusted by fine screws. It is easy to read to $\frac{1}{1000}$ inch, and therefore to measure a pressure which is balanced by a column of ether $\frac{1}{2000}$ inch high.

In order to learn how to connect the readings of the instrument with the speed of the air operating on it, it was determined not to depend on calculation only, but to test it against currents of air of known speeds. For this purpose a pipe was constructed fourteen inches diameter and 100 feet long, one end being in connexion with a tall chimney, the other one open. At the open end a hot brick was placed, and at a given signal a drop of sulphuric acid was allowed to fall upon it. The cloud of vapour thus raised passed along the pipe, and its arrival at the distant end was observed on looking through two holes bored for the purpose. The time was noted by a watch held to the ear. Having thus ascertained by two or three trials the speed of the air, readings from the ether-anemometer were taken. The speed was then altered by means of a slide or damper, and measured again by noting accurately the time taken by the cloud of vapour in travelling the 100 feet, and a fresh reading of the anemometer registered. In this way a Table was made embracing the greatest range of speed obtainable by the chimney.

It was clear from the law of bodies in motion, that this should obey the formula $p=v^2\times c$; where $p =$ the indication of the instrument, $v =$ velocity of the current, and c some constant influenced by the individual details of the instrument. From the series of experiments thus made, the value of c was found to be 25·31: with this a complete table of the values of p from 0·001 inch to 1·000 inch was calculated.

The instrument is found to be very satisfactory and reliable in its indications.

It may also serve as a wind-gauge. A plain piece of iron gas-pipe projecting vertically above the roof of the house or observatory, should communicate with one limb of the ether-anemometer. As the wind blows over the open end of this pipe, a partial vacuum would be formed and measured by the instrument. An advantage of this arrangement over the wind-gauges at present in use would lie in the absence of all moving parts whose friction might vary, and which might possibly be deranged.

TABLE *to show the Speed of Currents of Air as indicated by the Ether Manometer.*

$$v. = \sqrt{p.} \times 25{\cdot}31.$$

Temp. 60° Fahr. Bar. 30 inches.

Manometer-reading. Inches.	Speed of Air. Feet per second.	Manometer-reading. Inches.	Speed of Air. Feet per second.	Manometer-reading. Inches.	Speed of Air. Feet per second.
0·001	0·800	0·040	5·064	0·300	13·872
0·018	3·397	0·050	5·648	0·400	16·011
0·020	3·580	0·100	8·005	0·500	17·901
0·030	4·385	0·200	11·328	1·000	25·310

On the Refraction Equivalents of Salts in Solution. By Dr. GLADSTONE, *F.R.S.*

The object of this paper was to describe some preliminary observations on the effect which various salts dissolved in water exert on a ray of light transmitted through them. The author in this way expected to arrive at the refraction-equivalents of all the metals, and of the substances capable of combining with them to form soluble compounds. As yet, however, he rather indicated the method than the results, as he was unprepared to give precise numbers.

Experiments for the Verification of the Laws of Dr. Henry and Dalton on the Absorption of Gases by Liquids. By Dr. N. DE KHANIKOF.

The fact of absorption of gases by liquids was known by natural philosophers at the end of the seventeenth century, but the first serious observations on this subject were made by Cavendish and Priestley.

At the beginning of this century, in the Philosophical Transactions (1803, part 1, pp. 29–42), Dr. Henry published a very important memoir, "Experiments on the Quantity of Gases Absorbed by Water," in which he formulates the law of absorption in the following manner: "The results of at least fifty experiments on carbonic acid, sulphuretted hydrogen gas, nitrous oxide, oxygenous and azotic gases, establish the following general law—*that under equal circumstances of temperature, water takes up, in all cases, the same volume of condensed gas as of gas under ordinary pressure.* But as the spaces occupied by every gas are inversely as the compressing forces, it follows *that water takes up, of gas condensed by one, two, or more additional atmospheres, a quantity which, ordinarily compressed, would be equal to twice, thrice, &c. the volume absorbed under the common pressure of the atmosphere.*" This law was accepted without change until now.

Nevertheless it was evident that so simple a relation between the power of absorption of gases by liquids and the pressure, could only be considered as a rough approximation, and that in reality a phenomenon so intimately connected with the molecular structure of the liquids could not be expressed in such a simple form, because the unlimited admission of this law compelled one to admit also an unlimited absorption of gases already known to be impossible for *all* gases, especially for the condensible ones. Dr. Henry, from the nature of the apparatus he constructed for his researches, could not come to any other conclusion. His apparatus consisted simply of a glass bell, in which he introduced the absorbing liquid and the absorbable gas. This bell was connected with a manometer by a tube of india-rubber, and after the establishment of the required pressure, could be separated from the manometer and shaken by the observer a long time, for producing the total absorption. This construction had two great imperfections:—1st, it did not admit of a pressure of more than three atmospheres without forcing the joint; and 2ndly, the long contact of the hands of the observer with the bell made very uncertain the evaluation of the temperature of the gaseous volume before and after the absorption. Saussure repeated the experiments of Dr. Henry without changing considerably his apparatus, and came naturally to the same result. Nearly forty years after, Prof. Bunsen, of Heidelberg, made a valuable series of experiments on the absorption of gases at different temperatures, but the ingenious apparatus he

invented for this purpose could be employed only under the ordinary pressure of one atmosphere, and left untouched the relation established by Dr. Henry and Dalton between absorption and pressure. Lately Messrs. Roscoe, Ditmar, and Simms have made very interesting investigations on the absorption of some highly absorbable gases, and showed that the law of Henry and Dalton is only exact for elevated temperatures. That was the reason which induced my friend Dr. Louguinine and myself to undertake a new series of experiments on a gas not so absorbable as those investigated by Messrs. Roscoe, Ditmar, and Simms—namely, on carbonic acid gas.

Before all it was absolutely necessary to construct an apparatus which should not have the above-mentioned imperfections of the apparatus of our celebrated predecessor Dr. Henry. It was evident that it must consist of a glass vessel exactly gauged and arranged in such a manner as to be easily put in connexion with a large manometer, and separated from it in a very short time. Secondly, the absorption must be produced, not by shaking the apparatus by the hand, but by moving it mechanically in a space with an invariable temperature. The first requirement was easily obtained by luting to the open end of our absorption-bell an iron tube with a cork, and the second by taking the precaution of making the contact of the absorbing liquid and the absorbable gas very perfect by revolving the glass vessel, containing the liquid and the gas, in a great mass of water, maintained constantly at the same temperature. These are the two principal differences between our apparatus and those of our predecessors; and without entering into more details on our experiments, executed at the *Collège de France* in the laboratory of M. Regnault, I pass directly to the results we obtained for carbonic acid gas, and at the temperature of 15° C. or 59° F.

If we designate by α_1 the coefficient of absorption of a given gas under the pressure P_1, and by α_2 the coefficient of the same kind, but under a higher pressure P_2, by the law of Henry and Dalton we must have $\alpha_2 : \alpha_1 = P_2 : P_1$, or $\frac{\alpha_2}{\alpha_1} - \frac{P_2}{P_1} = 0$, or $a - b = 0$; if we designate by a, $\frac{\alpha_n}{\alpha_{n-1}}$, and by b, $\frac{P_n}{P_{n-1}}$. The following Table contains the values of a and b given by our experiments:—

a.	*b.*	*a−b.*
1·2307	1·1595	0·0712
1·9751	1·8480	0·1271
2·2903	2·1068	0·1835
3·0797	2·8694	0·2103
3·3644	3·1369	0·2275
3·6920	3·3938	0·2982
3·9351	3·6605	0·2746
4·2401	3·9247	0·3152
4·7671	4·4567	0·3104

In spite of some small anomalies presented by these numbers, it is evident that the difference $a - b$ is constantly increasing with the pressure, so that this discrepancy with the law of Henry and Dalton cannot be ascribed exclusively to the inevitable errors of observation.

From the moment that the carbonic acid gas was liquefied, it was evident that its coefficient of absorption by liquids must be zero for two different pressures. First, for a pressure of nearly zero; and second, for the pressure which reduced the gas, at a given temperature, to a liquid state. But if so, it was also evident that the relation between the coefficient of absorption and the pressure could not be a simple algebraical and lineal function of these variables, as it was supposed by Henry and Dalton, but that this relation could be more nearly expressed by

$$\alpha = A + BP + CP^2,$$

which for $\alpha = 0$ must give two positive and real values for P, and also

$$\alpha = -A + BP - CP^2 \text{ and } B > A \text{ and } C < B.$$

Applying to this equation, for the different values of α and P obtained by our

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experiments, the method of least squares, we find for A, B, and C the following values:—

$$A = -0{\cdot}13259174 \text{ with mean probable errors for } A = \mp 0{\cdot}01520946$$
$$B = +4{\cdot}21442268 \text{ with mean probable errors for } B = \mp 0{\cdot}01393995$$
$$C = -0{\cdot}01982625 \text{ with mean probable errors for } C = \mp 0{\cdot}00283004.$$

These values of A, B, and C being put in the equation $\alpha=0$, give us the two numerical expressions of P, which render the coefficient of absorption equal to zero, namely, P=0·109 atm. and P=61·144 atm. At the same time we see that α becomes a *maximum* for P=30·66 atm., and that for this pressure it will be nearly 18 times greater than when P=1. The value of P=61 atm. is evidently the pressure required for the liquefaction of carbonic acid gas at the temperature of 15° C., and we have no direct experiments for the verification of this number; but if we take the observations of M. Regnault on the points of ebullition of liquid carbonic acid gas at different pressures, we obtain the following Table:—

Difference of temperature.	Temperature.	Press. in atm.	Difference of pressure.
	−73·3 C.	1·8	
16·6			3·5
	−56·7	5·3	
16·7			5·8
	−40 0	11·1	
11·1			5 2
	−28·9	16·3	
16·7			10·5
	−12·2	26·8	
11·1			11·4
	− 1·1	37·2	

If we calculate by means of this Table the pressure necessary to liquefy carbonic acid gas at the temperature of 15° C., we obtain exactly the number 61·1 atmospheres.

Without attaching more importance than they deserve to the above-mentioned numerical expressions of A, B, C, and α and P *maxima*, &c., which cannot be strictly exact, as being concluded from a too limited series of experiments, I have mentioned them only for showing that our method of experimentation can give us, in a comparatively easy way,—

1st. The values of pressure required for the liquefaction of gases; and,

2ndly. The numerical value of the maximum of absorption of every gas, varying only with the nature of the gas and with the temperature.

Preliminary Notice of Results on the Composition of Wheat grown for twenty years in succession on the same Land. *By* J. B. LAWES, *F.R.S., F.C.S., and* J. H. GILBERT, *Ph.D., F.R.S., F.C.S.*

These results had reference to the produce of a field in which wheat had now been grown, on some plots without manure, on one with farm-yard manure, and on others by different artificial mixtures, for twenty-four years in succession (1843-4 to 1866-7 inclusive). At the Cheltenham Meeting of the British Association in 1856, the authors treated of the effects of season and manures on the composition of the crop as illustrated by the results of analysis relating to the produce of some of the plots during the first ten years of the experiments*. At the Manchester Meeting, in 1861, they recurred to the subject; the analytical results, which then extended to the produce of some of the plots for sixteen years, were, however, chiefly applied to the illustration of certain points in connexion with the exhaustion of soils. At the Nottingham Meeting, in 1866, they treated of the accumulation of the nitrogen of manure in the soil of the same experimental field. The results adduced on the present occasion showed the effects of season and manuring on the composition of both the grain and the straw during twenty years of the experimental growth.

The particulars of composition given are—the percentages of dry substance, of mineral matter, and of nitrogen, and the constituents of the ash of both grain and straw, more than 200 complete ash-analyses being brought to bear on the subject; and, side by side with these, as indicating the general characters of the

* "On some points in the Composition of Wheat-grain, its products in the Mill, and Bread," Journ. Chem, Soc vol. x.

produce of the different seasons and plots, are given the proportion of corn to straw, and the weight per bushel of the corn.

In the case of the plots without manure, with farm-yard manure, and with ammonia-salts alone, every year, the ash of the grain of the last sixteen, or more, and of the straw of the last sixteen, of the twenty years, had been analyzed; and in the case of nine differently manured plots (including the above three), the ash, of both corn and straw, of the first, the last, and two intermediate seasons (one bad and one good) of the last twelve of the twenty years had been analyzed. It was the intention of the authors to publish the results of the investigation in detail before long; and on the present occasion they confined attention to a few of the most prominent effects of the respective manures on the composition of the crop, when thus applied for so long a continuance, year after year, on the same plot.

It is first pointed out as remarkable, though fully established by their results from the commencement, that variation in manure, even though maintained for many years in succession, and resulting in great variation in amount of produce, affects comparatively little either the proportion of corn to straw, or the weight per bushel of the corn; excepting, indeed, in a few extreme cases of abnormal exhaustion or repletion. Nor do the percentages of dry substance, of mineral matter in dry substance, or of nitrogen in dry substance, vary much under the direct influence of variation in manure, unless again in very abnormal cases. Very different, however, is the effect of season; the variation in the character of the produce, in every one of the above particulars, being much greater in different seasons with the same manure, than with different manures in the same season.

Consistently with these broad facts, the composition of the ash of the grain is found to be pretty uniform under a great variety of manurial conditions in one and the same season; only in a few extreme cases, of special interest, varying in any material degree. The same may be said in some, though in a much less degree, of the composition of the ash of the straw, which is obviously much more directly affected by the character of the supplies within the soil.

The general result is that (excepting in a few abnormal cases), the variation in the composition of the ash of the grain is limited to the slight variations due to differences of development and maturation, which, in their turn, are much greater with variation of season than with variation of manure. The composition of the ash of the straw, on the other hand, much more nearly represents the total mineral matters taken up by the plant, and much less the character of development of its own more fixed and essential constituents. In other words, whilst there may be considerable range in the composition of the matters taken up by the entire plant, the tendency in the formation and ripening of the ultimate product, the seed (whether produced in small quantities or large), is to a fixed and uniform composition, the deviation from which is little directly affected by the character of the supplies within the soil, but much more by the various influences of season.

The deviations from the point of fixed and uniform composition, thus due primarily to variations in climatic circumstance, are, however, when considered in relation to other characters of the grain, sufficient to show the general connexion between the comparative predominance of individual constituents and that of certain general characters of development. A few illustrations were given, but the fuller treatment of the subject, in its bearing on these as well as on other points, was reserved until the results could be considered in the detail necessary to their proper elucidation.

One point of interest prominently brought out by the results relating to the composition of the straw-ash was, that a high percentage of silica was almost uniformly associated with a bad, and a low percentage with a good condition of the produce; a fact to which the authors had on former occasions called attention, but which, as was remarked by the President, was quite inconsistent with the generally accepted views on the subject.

Notes of the Analyses of Gold Coins of Columbia, New Granada, Chili, and Bolivia; with some account of the operations of Gold Mining in Nova Scotia. By GEORGE LAWSON, *Ph.D., LL.D., Professor of Chemistry, Dalhouse College, Halifax, U.S.*

On the present Uses of Lichens as Dye-stuffs.

By W. LAUDER LINDSAY, *M.D., F.R.S. Edinb., F.L.S.*

The paper treats of the subject under two principal heads, viz.:—

I. The *Commercial* Dye-lichens and Lichen-dyes: and

II. The *Domestic* Dye-lichens and Lichen-dyes.

When the aniline colours were introduced some years ago, technologists predicted with confidence the rapid disuse of lichen-dyes, on the ground of the superior beauty and permanence, as well as abundance and cheapness, of the former. In like manner, many years ago, scientific authorities ventured to assert that if there lingered then in the more remote corners or less accessible districts of Scotland any vestige of the domestic or *home-use* of lichens as dye-stuffs—a practice which at one time largely prevailed—such a rude procedure or custom would speedily disappear before the march of civilization, the penetration of the Highlands by railways, the establishment of regular steam communication between Edinburgh or Glasgow and the western and northern islands, the cheapening and multiplication of coal-tar and other dye-stuffs, and of the printed goods (woollen and cotton) of Glasgow and Manchester, Hawick, and Leeds. Investigations made in the course of collecting materials for a work on British Lichenology, in preparation by the author (including the results of an examination of the International Exhibitions of London and Paris, an inspection of the orchill manufactory of Messrs. Burton and Garraway of Bethnal Green, London, and of a tour through the Hebrides, Orkney, and Shetland in May and June 1866) have led him to the conclusion that all such predictions or assertions, whether regarding lichens as commercial or domestic dye-stuffs in England and Scotland, are at least premature, and that there is abundant evidence of a long future of usefulness for lichen dye-stuffs in this and other countries.

Under the head of

I. *Commercial* Dye-lichens and Lichen-dyes,

the author's chief propositions are the following:—

1. French colorists especially appear to have devised new processes for ensuring *permanence* of lichen-dyes, whereby they can now quite compete in this respect with the aniline colours, to which they have never been inferior in point of beauty.
2. New forms of lichen-dyes have been patented; especially combinations of orchill liquor, or its equivalent, with alkalies or earths in the form of lakes, whereof the most familiar and important is that known as "*French purple*," the patent of Messrs. Guinon, Marnas, and Bonnet of Lyons, by whom it was exhibited in London in 1862.
3. While the older dye-lichens have gradually been given up, *new* and *more valuable* tinctorial species have been introduced: or the use of some of those which were at one time little familiar, has now become greatly extended. Manufacturers now import almost exclusively the *Roccellæ*; and for the most part *Roccella fuciformis*, or its allies or varieties, as these occur on *trees* in *tropical* or subtropical countries, near the *coasts*.
4. The finest tinctorial forms of *Roccella* are *Equatorial*, growing within the limits of 10° north and south of the Line.
5. The "orchella weeds," at present of greatest value in the British market, are

    1. Mozambique,
    2. Ceylon,
    3. Angola,
    4. Lima and Bombay } equal,
    5. Cape Verde,

    } "Orchella weeds."

6. The principal importers of "orchella weeds" are the Portuguese, French, and English.
7. The same species of *Roccella* possesses very different tinctorial qualities, according to its geographical source.

8. It is impossible to foretell or estimate the colorific value of any given new sample of "orchella weed" by any tests or series of chemical or other experiments *on the small scale.* It can be determined only by manufacture *on the large scale*; and as this is an experiment that necessarily involves the risk of heavy pecuniary loss, it is not surprising that new materials and new processes are accepted or adopted with unusual tardiness or caution.
9. The substitution, as an article of import, of the *colorific principles* for the bulky dye-lichens themselves has not yet been adopted by manufacturers, though recommended strongly by chemists.
10. New commercial sources of valuable tinctorial *Roccellæ* have been discovered —new markets opened up. Their present chief geographical sources are,

    1. Africa and its islands.
    2. South America; and
    3. India and its islands.

11. The commercial sources of "orchella weeds" of the finest quality may yet be greatly multiplied, and are so far from being exhausted, that they cannot yet be said to be fully developed or discovered.
12. The only visible effect of competition with other dye-stuffs has been greatly to reduce the market value of "orchella-weeds."
13. Nevertheless, their products—French purple, orchill, and cudbear—are successfully competing with the aniline, and all other colours, of their class hitherto introduced.
14. So far from being superseded, the import of dye-lichens and manufacture of lichen-dyes in Europe is, perhaps, now more extensive and more flourishing than at any previous period.
15. The manufacture of lichen-dyes in this country has not reached perfection; and if with all their imperfections of manufacture they can successfully compete with aniline, whose preparation and applications are much more highly scientific, they have little reason to fear competition in the future, when applied chemistry shall have lent its aid to their proper production and applications.

Under the head of

II. *Domestic* Dye-lichens and Lichen-dyes,

the author's chief propositions are as follow:—

1. The domestic use of lichen-dyes is prevalent over whole districts in Scotland, —even in and around large seaports, which have steam communication with Glasgow or Edinburgh, sometimes two or three times a week (*e. g.* Stornoway), and which may be presumed therefore to be well supplied with the cheapest and most abundant products of British manufacture.
2. In the outer Hebrides (Lewis and Harris) "Crottle *" (*Parmelia saxatilis*) is universally used in the dyeing of

    a. "Kelt," a home-made cloth.
    b. Stockings and socks.
    c. Polkas and scarfs.
    d. Hearthrugs and other articles.

3. The articles of clothing so dyed are disposed of *by barter* to the merchants

* The term "Crottle" or "Crotal" is also applicable generically to dye-lichens. With various descriptive prefixes, it has been, or is, applied in different parts of the United Kingdom to other species of *Parmelia*, as well as to species of other genera, *e.g.*, to

Parmelia saxatilis, var. *omphalodes* = black crottle.
P. physodes = dark crottle.
P. caperata = stone crottle.
Lecanora tartarea = (par excellence) crottle.
L. parella = light crottle.
Isidium corallinum = white crottle.
Sticta pulmonacea = hazel crottle.

Vide the author's work on 'British Lichens' (1856), p. 336.

of Stornoway; and are subsequently to be met with in the southern markets (*e. g.* Glasgow).

4. *Cudbear* is also largely used in the same islands (Lewis and Harris), being imported from southern markets *via* Glasgow.
5. In Caithness and Sutherland a similar use is made of "Crottle," Thurso being the market and seaport to which the home-dyed produce is consigned *by barter.*
6. Similar use is made of "Crottle" and other lichens (*e. g. Lecanora tartarea, Ramalina scopulorum, Sticta pulmonacea*), in Lochaber, Badenoch, and other parts of the Scottish Highlands.
7. The process of dyeing varies greatly in different districts, *ammoniacal maceration* being apparently unknown in the Hebrides, while it is or was generally adopted in the central Highlands.

The conclusion of the paper is occupied with observations on the present unsatisfactory character or condition of

1. The *chemistry* of lichens, and more especially of the lichen-dyes.
2. The lichen-exhibitions in our national Museums; and
3. Lichenological literature; so far at least as this is represented by standard works of reference—Botanical and Chemical.

In regard to the first subject of complaint, he advocates a new series of researches to be undertaken *conjointly by competent chemists and lichenologists*, so that the one may assist or correct the investigations of the other: in reference to the second, a systematic arrangement, by competent lichenologists and chemists, with proper periodic supervision and rearrangement; and as concerns the third, the consultation, by compilers, of original recent works of research instead of repetition at second hand of the obsolete notions and errors of the earlier authors.

On a New Synthesis of Ammonia. By P. T. MAIN *and* A. R. CATTON.

Note on the Artificial Production of Oil of Cinnamon. By W. L. SCOTT.

On the Bisulphite of Calcium as a Preservative of Animal Substances. By W. L. SCOTT.

On a Compound formed by the direct union of Aldehyde and Anhydrous Prussic Acid. By MAXWELL SIMPSON, *M.D., F.R.S., and* A. GAUTIER, *M.D.*

The synthesis of alanin from aldehydate of ammonia, prussic and hydrochloric acids, and the formation of lactic acid by the action of the same acids upon aldehyde, render highly probable the existence of an intermediate body, resulting from the direct union of prussic acid and aldehyde, the formation of which constitutes the first phase in these reactions. It is this body which forms the subject of the present paper.

If one molecule of anhydrous hydrocyanic acid be added to one molecule of dry aldehyde, contained in a balloon surrounded with a freezing mixture, the two liquids mix without combining chemically, and their chemical combination is not accelerated by heating at 100° C. If, however, we leave them in contact for ten or twelve days at the ordinary temperature of the air, they gradually unite, forming a perfectly transparent and colourless liquid. On subjecting this to distillation, it was observed that hardly a drop passed over under 100°; a small quantity between 160° and 174°, and the remainder of the liquid between 174° and 185° C. On redistilling the latter portion it was found that the greater part passed over at about 183° C. A considerable quantity, however, came over between 40° and 60°, consisting principally of the parent bodies, which had been dissociated by the simple vaporization of the liquid.* On leaving these bodies thus dissociated once more in contact for some days, the point of ebullition rose as before to 183° C.

* The liquid was distilled with great rapidity.

The fractions distilling at 180° and between 183° and 184° C.* gave on analysis the following results:—

	Product boiling at 180° C.	Product boiling between 183°–184° C.	Theory, CNH,C_2H_4O.
C	49·78	51·70	50·71
H	7·44	7·64	7·04
N	20·42	——	19·83

These analyses prove that the body in question results from the direct combination of one molecule of aldehyde and one molecule of prussic acid, or at least of equal numbers of molecules of these bodies, and that its point of ebullition is intermediate between 180° and 184°. We have tried the above experiments on mixtures containing the two generating bodies in various proportions, but always with the production of the same compound. The name we propose for this body is cyanhydrate of aldehyde, which is simply founded upon its synthetical formation.

Properties.—The cyanhydrate of aldehyde is a colourless liquid, having a faint odour of its generators; it has a bitter and acrid taste; it does not crystallize at −21° C., but becomes syrupy. It can bear the temperature of 150° for a considerable time without suffering decomposition; at 180°, however, slight dissociation commences, and the liquid must be rapidly distilled in order to avoid the loss of a considerable quantity. It is soluble in all proportions in water and alcohol. It may be heated with water in a sealed tube to 150° without suffering the slightest decomposition, and the entire liquid can be recovered by distillation. Caustic potash appears to separate it into its two generators, forming cyanide of potassium and resin of aldehyde. A little ammonia is also evolved, owing probably to the decomposition of the cyanide of potassium.

Gaseous ammonia is absorbed by cyanhydrate of aldehyde, with the production of a base, which gives a precipitate with bichloride of platinum. Our analyses of this salt have not yet enabled us to ascertain the composition of the base.

A strong solution of hydrochloric acid acts with great violence at the ordinary temperature of the air upon cyanhydrate of aldehyde. If, however, the cyanhydrate be introduced into a balloon surrounded by a freezing mixture, and the hydrochloric acid be added gradually, the two liquids mix without any reaction taking place. On removing the balloon from the freezing mixture and placing it in water at the ordinary temperature, the reaction soon commences, and proceeds gradually till the entire liquid becomes a mass of crystals. These were twice treated with absolute alcohol in order to separate the chloride of ammonium which is formed. On evaporating the alcoholic solution a syrupy liquid was obtained, which was saturated at 100° with pure oxide of zinc and filtered. The filtered liquid gave, on cooling, a mass of beautiful prismatic crystals. These were recrystallized, heated in an oil-bath to 150° C., and analyzed. The numbers obtained prove that the body in question was the lactate of zinc, as will be seen from the following Table:—

	Experiment.	Theory, $C_3H_5ZnO_3$.
C	29·84	29·63
H	4·52	4·13
Zn	26·77	26·75.

The following equation explains the formation of this acid:—

$$C_2H_4O,\ HCN+HCl+2(H_2O)=C_3H_6O\ +NH_4Cl.$$

The insolubility of this salt in alcohol, its non-decomposition at 150°, and its crystalline form, sufficiently prove that the acid combined with the zinc was the lactic acid of fermentation, and not the sarcolactic.

The behaviour of cyanhydrine of aldehyde towards hydrochloric acid and caustic potash, proves that it is isomeric and not identical with the cyanhydrine of glycol discovered by Wislicenus.

We have endeavoured to obtain the vapour-density of this body by Dumas's method, but without success. On heating the balloon containing our body to 210° in an oil-bath, we observed, on removing it from the bath, that the aldehyde had been converted into a resin. On deducting its weight from the weight of the balloon, the density of the vapour approached very near that of prussic acid. It appears to us, however, to be sufficiently proved that this compound contains only

one molecule of each of the parent bodies, from the fact that it gives lactic acid with hydrochloric acid, and that it separates by the action of heat into prussic acid and ordinary aldehyde, and not into a polymer of aldehyde such as elaldehyde or paraldehyde.

The cyanhydrate of aldehyde is, in our opinion, a very striking example of an organic compound which the temperature of vaporization decomposes, and the prolonged action of time reconstructs.

On the Formation of Succinic Acid from Chloride of Ethylidene. By Maxwell Simpson, *M.D.*, *F.R.S.*

Some years ago * I ascertained that when bromide of ethylene is successively treated with cyanide of potassium and caustic potash, ordinary succinic acid is formed. This reaction has since been confirmed by M. Geuther †, who, however, employed chloride instead of bromide of ethylene.

It occurred to me that it would be interesting to ascertain whether the chloride of ethylidene would, when subjected to the same treatment, produce the same or an isomeric acid. One would naturally expect the latter result, seeing that the constitution of the chloride of ethylidene is different from that of the chloride of ethylene. The following formulæ will make this intelligible, and show the probable constitution of the isomeric acid:—

CH_2Cl | CH_2Cl	CH_2Cy | CH_2Cy	$CH_2(COOH)'$ | $CH_2(COOH)'$
Chloride of ethylene.	Cyanide of ethylene.	Ordinary succinic acid.
CH_3 | $CHCl_2$	CH_3 | $CHCy_2$	CH_3 | $CH(COOH)_2$
Chloride of ethylidene.	Cyanide of ethylidene.	Isomeric acid.

It is to be observed that in the transformation of cyanide of ethylene into ordinary succinic acid, the group COOH takes the place of each equivalent of cyanogen. In the transformation of cyanide of ethylidene, it is to be supposed that the cyanogen is replaced in a similar manner, with the formation of an isomeric acid.

In order to determine this point, I made the following experiments:—

A mixture of one equivalent of pure chloride of ethyle chloré, which is identical with the chloride of ethylidene, two equivalents of pure cyanide of potassium, and a large quantity of alcohol was exposed in a sealed matrass for twenty-seven hours to a temperature ranging between 160° and 180° Cent. I had previously ascertained that a high temperature was necessary in order to produce a reaction. At the expiration of the above-mentioned time the matrass was opened and its contents filtered. The filtered liquor was then treated with solid potash, and afterwards exposed to the temperature of a water-bath till ammonia ceased to be evolved. When this was observed, the alcohol was distilled off, and nitric acid added in excess to the residue. Finally, this was evaporated to dryness at a low temperature, and the liberated organic acid taken up by alcohol. By dissolving in absolute alcohol, and crystallizing from water, the acid was obtained quite pure. The quantity of acid formed was not large. Dried at 100° Cent., it gave the following numbers on analysis:—

	Theory. Succinic acid.		Experiment.
		per cent.	
C^4	48	40·67	40·86
H^6	6	5·10	5·55
O^4	64	54·23	„ „
	118	100·00	

* Philosophical Transactions for 1861.

† Annalen der Chemie und Pharmacie, Band cxx. S. 268.

It had, then, the composition of succinic acid. That it was the ordinary acid was sufficiently proved by the following properties and reactions:—It melted at 179° Cent., and sublimed in the form of needles on the application of a higher temperature. The vapour produced, on being inhaled, instant coughing and a painful sensation in the nostrils. The neutralized acid gave an abundant brown precipitate on the addition of perchloride of iron. This test was tried both before and after the body in question had been treated with nitric acid, and with the same result.

The only explanation I can give of the formation of ordinary succinic acid in this case is, that the chloride of ethyle chloré was, in presence of the cyanide of potassium, partially converted, by the high temperature to which it had been subjected, into chloride of ethylene, one equivalent of hydrogen changing its place with one equivalent of chlorine:—

$$\begin{matrix} CH_3 & & CH_2Cl \\ | & = & | \\ CHCl_2 & & CH_2Cl. \end{matrix}$$

Since the above was written I perceive that M. Wichelhaus* has formed the isomeric acid from cyanpropionic acid. The difference between it and the ordinary acid is well marked. Its melting-point is 40° lower, and it does *not*, when neutralized, give a precipitate with perchloride of iron.

These results correspond, to a certain extent, with the researches of M. Caventou, who has shown that ordinary glycol can be obtained from the bromide of ethyle bromé.

On the Gaseous Products of the destructive distillation of Hydrocarbons, obtained from Shales and Coals at Low and High Temperatures. By R. F. Smith.

On the Economization of Sulphurous Acid in Copper Smelting. By Peter Spence, *F.C.S.*

Lord Derby (in 1861) obtained the appointment of a committee of the House of Lords for obtaining evidence as to the noxious vapours from chemical and other works. That investigation, carried over many months, resulted in the passing of the Alkali Works Act, so ably and successfully carried out by Dr. Angus Smith as inspector.

A large amount of evidence was elicited by the committee as to the emission of sulphurous acid and arsenious acid from the copper smelting works of Swansea and other parts of the kingdom, but no legislation was adopted as to these works, because, with the exception of the writer of this paper, all the witnesses testified to there being no practicable means of suppressing the acknowledged nuisance without destroying the trade.

The object of this paper is to show that the means then proposed to the Lords' Committee by the writer for, to a large extent, suppressing this nuisance, by the conversion of the sulphurous acid into sulphuric acid by the aid of furnaces of the writer's invention, have since then been in large and successful operation at the Goole Alum and Smelting Company's works at Goole in Yorkshire, who are at this present time smelting 200 tons per week of copper ores, four-fifths of the sulphur which these ores contain being converted into sulphuric acid.

About two months previous to the reading of this paper the writer sent one of his chemical assistants to Goole to superintend, during a month, some large experiments in the ordinary course of work, analyzing the results at every stage, so that reliable data might be obtained.

One of these experiments is given, and as it is typical of the general operations, it may be taken as indicating what is being done.

$10\frac{1}{2}$ tons Cornish ores, containing 19 per cent. sulphur.
$13\frac{1}{2}$ tons Spanish smalls, containing 47 per cent. sulphur.

24 tons.

* Zeitschrift fur Chemie, Neue Folge iii. Band, S. 247.

	Total sulphur. Tons.	cwt.	qrs.	lbs.
These ores mixed gave 33·3 per cent. of sulphur........=	8	0	0	0
The ore calcined, the SO_2 all going to the vitriol chamber, yielded 22 tons calcined ore, containing 8 per cent. sulphur ....=	1	15	0	0
The whole smelted gave of regulus 2 tons 15 cwt., containing 28 per cent. sulphur ....=	0	15	1	20
Loss of sulphur in this stage	0	19	2	8
The 2 tons 15 cwt. regulus was calcined, the SO_2 again going to the vitriol chamber, and gave 2 tons 10 cwt. containing 9 per cent. sulphur.........................=	0	4	2	20
All which must be dissipated—loss	1	4	1	0
Sulphur economized	6	15	3	0
	8	0	0	0

Or

Sulphur economized .... 84·8 per cent.
Sulphur lost .... 15·4 per cent.

On the Preservation of Stone. By JOHN SPILLER, *F.C.S.*

For several years past the author has been studying the causes of the decay of stone, and experimenting with such chemical reagents as appeared to offer any promise of being usefully applied as means of prevention. At an early stage of the investigation it seemed probable that the corrosive action of sulphurous and sulphuric acids in the atmosphere, resulting from the combustion of coal fuel, would operate, in large towns especially, in a destructive manner upon dolomite and the numerous class of limestones commonly employed in public buildings. This chemical action, aided by the simultaneous attack of carbonic acid and moisture, and in the winter season further supplemented by the disintegrating effects of frost, are conceived to furnish a sufficient explanation of all the facts observed. Dr. Angus Smith, Mr. Spence, and others having already directed attention to the immense scale of production of these sulphur-acids, the author proceeded to quote statistical data showing the extent or degree of pollution of the air from this cause in the manufacturing districts of Lancashire. Numerous samples of dolomite, Caen, Bath, and Portland stones fresh from the quarry have been tested, but without finding more than a trace of ready-formed sulphate, whereas scrapings taken from the decayed portions of the stone of the New Palace at Westminster were bitter to the taste, in consequence of the comparatively large amount of sulphate of magnesia formed during a few years' exposure to the sulphurous gases occurring in a metropolitan atmosphere. Caen stone from several buildings and localities, Portland stone, and even old faces of chalk cliff in the neighbourhood of Woolwich, were in like manner found to contain appreciable quantities of the sulphate of lime, having undoubtedly a similar origin. A close examination into the circumstances attending the decay of stone at the Houses of Parliament invariably shows an increased liability to corrosion under the projecting eaves and mouldings, and at such sheltered parts of the stone surfaces as are usually covered with soot and dust, and are in a position to retain for the longest period the moisture absorbed during a season of rain. In many cases the disintegrated stone exhibits white crystals of the sulphate of magnesia, which alternately dissolving and recrystallizing in the pores of the stone, may be conceived to exert a disruptive action sufficient to account for the scaling and fracture of the dolomite, which has been so often observed. With the view of overcoming some of these difficulties, the author submitted a plan to the Royal Commissioners charged with inquiring into the decay of stone at Westminster, in May 1861, which consisted in the application to the cleaned surfaces of the stone of an aqueous solution of superphosphate of lime—a salt remarkable for its action in hardening the surfaces of chalk, Caen stone, or other calcareous building-stone to which it may be applied, either by brushing or immersion, and which acts upon the carbonate of lime in the stone,

giving rise to the formation of Bödeker's salt (crystallized diphosphate of lime—$2CaO, HO, PO_5 + 4\ Aq$). This suggestion received a practical trial at the Houses of Parliament, in a competition to which five other candidates were admitted by the Right Hon. the First Commissioner of Her Majesty's Works in April 1864.

Another promising scheme for the treatment of the decayed stone, especially applicable to dolomite, consists in the employment of baryta conjointly with the hardening salt, so that a base may be presented which is endowed with the power of destroying the soluble sulphate of magnesia in the pores of the stone, forming with it the remarkably insoluble sulphate of baryta, and at the same time engaging the magnesia in one of its most difficultly soluble combinations. On a recent occasion this process was applied to some Caen-stone facings at St. John's Church, Woolwich, which were badly decayed. Several examples of the application of the superphosphate to decayed Caen, stone were referred to; and with respect to Portland stone, the earliest experiments were said to have been made at the Army Clothing Establishment, Woolwich, where (in 1861) some decayed window-sills were treated with perfect success.

In connexion with the treatment of Portland stone, some interesting results were then described, which serve to illustrate the increased hardness and strength, and the diminished rate and capacity of water-absorption attending the employment of the superphosphate. By treating small cubes of Portland stone with the phosphate solution, and when dry subjecting them to gradually increasing pressure until crushed between plates of lead in the American Testing Machine at the Royal Gun Factory, it was found that the *breaking weight* of the stone was augmented by 50 per cent. The increased hardness of the stone after treatment could be readily ascertained by scratching with a pointed instrument of copper, which metal proved to possess a degree of hardness intermediate between the original and treated Portland stones. The porosity of the stone, as indicated by the amount of water absorbed, proved to be greatly diminished in the case of the treated cubes. The advantage of the process is most clearly apparent in the denser and more compact variety of Portland known as the "Whit Bed," which alone is employed for external building purposes; that known as the "Base Bed," is softer, and only fit for internal decoration, and its texture is so porous that in becoming saturated it absorbs nearly 10 per cent. of water. Samples of Mansfield dolomite absorbed amounts of water varying in different specimens from 6 to 8 per cent. After treatment by this process, the degree of absorption was reduced one half, and the results were even more favourable in the case of Caen stone. The cost of materials employed in the treatment of stone according to this plan is very trifling, and bears but a small proportion to the cost of labour necessarily expended upon the cleaning and preliminary preparation of the stone before the solution can be applied. One gallon of solution will cover about 250 feet superficial, when two coatings are applied upon Caen or Portland stone. The superphosphate employed must not contain any appreciable amount of sulphuric acid, and the specific gravity of the solution, when diluted for use, should be about 1·1.

On certain New Processes in Photography. *By* JOHN SPILLER, *F.C.S.*

Under this head were described several interesting improvements in photography, based on the chemistry of gelatine. The processes to which reference was made were the various modifications of the Woodbury type, including the new method of micro-photo-sculpture, the art of photolithography, as practised in the Royal Arsenal at Woolwich, and some illustrations of the use of gelatine or albumen, on a foundation of silk, satin, or cambric, the work of Mr. H. B. Pritchard, of the War Department. The Hon. H. Fox Talbot was one of the first to describe and make a practical use of the action of light upon a mixture of gelatine and a soluble bichromate, and after him Col. Sir H. James, Mr. Swan, of Newcastle, and Mr. Woodbury, of Manchester, have applied the same chemical principle in new directions. It is known that the chemical rays of light have the effect of rendering insoluble gelatine to which a bichromate has been added; and it would appear that this oxidizing salt hardens the animal substance by forming with it a combination

of chromic oxide. In proof of this view, it may be stated that Mr. Swan has lately devised a mode of working, in which a minute quantity of chrome alum or sulphate of chromium is used instead of the red chromate, and it is found that, when dried, this mixture is not again affected by water. The carbon prints of Mr. Swan, which were exhibited last year at Nottingham, are illustrations of the use of a chromate in conjunction with gelatine and pigments. Mr. Woodbury's process is also based on the insolubility of the chromo-gelatine after exposure to light, and upon the subsequent action of water upon a sensitive film, which has been in different degrees influenced by insolation under an ordinary photographic negative. The depths of tint in the original are represented by variations in the thickness of the film of gelatine left unacted upon by water, and this dried may then be used as a matrix to produce a corresponding series of depressions upon a surface of lead or type-metal by the aid of a powerful hydraulic press. The blocks so produced serve for printing off a great number of proofs when they are liberally "inked" with warm gelatine, highly charged with Frankfort black or other suitable pigment, and pressed down upon a smooth sheet of paper until the excess of ink is forced out on all four sides of the block and so removed from the space constituting the area of the picture, which, when set, is, lastly, protected with a varnish of collodion.

Mr. Woodbury has lately perfected a modification of his process, which is applicable to the representation in high relief of microscopic objects. The method consists in spreading a warm solution of gelatine, containing a little sugar and bichromate of potash, over a glass plate previously coated with collodion. The film sets on cooling, and is then placed in contact with an ordinary photographic negative of the microscopic objects to be delineated, exposed to light, submitted as before to the action of water, and the soluble portions washed away. When the surface moisture has evaporated, a mixture of plaster of Paris, containing a small proportion of alum, is poured over the relief to the thickness of half an inch, and left to set. When dry it will be found, owing to the alum in the plaster hardening the surface of the gelatine directly on coming in contact therewith, to leave the gelatine easily, without any fear of adhesion. To give a finished appearance to the resulting casts, this intaglio, when dry, may be placed in a lathe, and a suitable border turned on it, which will be represented in the resulting proofs by a raised border, similar to what is seen on medallions or plaster casts. The name of the object may also be neatly engraved on the intaglio, to appear in raised characters on the reliefs. This intaglio should then be well waxed to fill up the pores, and is ready for taking any number of impressions in plaster; or a better plan is to take one in plaster, and having smoothed away any defects, to mould a reverse in sulphur, which will give a greater number of fine impressions. The progress made during the year in perfecting the details of photolithography have led to the practical use of this art as a means of procuring on a reduced scale printed reproductions of the large series of lithographs issued for the use of the British army by the Royal Carriage Department. The steps followed in conducting this process were briefly described, and a variety of illustrations produced at a very low cost were exhibited. The issue of these photolithographs by the War Department has already attained to many thousands.

Synthesis of Caproic Acid. *By* J. ALFRED WANKLYN *and* ROBERT SCHENK.

Mercury-amyl was prepared by the process of Frankland and Duppa, and converted into zinc-amyl by prolonged digestion with zinc.

The purity of the mercury-amyl had been guaranteed by a determination of mercury which agreed with the theory.

The zinc-amyl was sealed up with sodium and heated in the water-bath. The action of the sodium is very slow. Having prepared sodium-amyl, we exposed it to the action of dry carbonic acid, which acted energetically, evolving heat. The product of the reaction was treated with water, evaporated down to dryness, and the residue distilled with dilute sulphuric acid. An oily acid distilled over, and was converted into a baryta salt. The baryta salt was submitted to analysis, giving results concordant with the theory. Carbonic acid, therefore, behaves with sodium-amyl just as with sodium-ethyl and sodium-methyl,

$$CO_2+NaC_5H_{11}=C_6H_{11}NaO_2.$$

On the Existence of Putrescible Matter in River and Lake Waters. *By* J. ALFRED WANKLYN.

Action of Sodium on Valerianic and similar Ethers. *By* J. ALFRED WANKLYN.

On the Electrical Resistances of the Fixed and Volatile Oils *. *By* T. T. P. BRUCE WARREN.

The want of an acknowledged and reliable means of recognizing the purity or condition of samples of oils has long been felt by pharmaceutists. No tests, or system of tests at present used, are free from objection. An inspection of the optical characters of the oils, whether fixed or volatile, will be sufficient to confirm the truth of this observation.

The polariscope has at best a very limited scope of application, whilst the determination of the refractive or dispersive qualities requires such precise adjustments that the suitability either of the one or the other for the purposes of a technical test may be fairly questioned. The refractive power of the oils, both fixed and volatile, has so small a variation, that the difference produced on the refractive power of any oil by the addition of a small quantity of another, would be barely perceptible. The objection against the measurement of the dispersive action as a means of expressing the value of an oil is, that the determination of the differences of indices of refraction for the extreme rays is at once tedious and unreliable; the scale of dispersions offers, however, a much wider range of differences.

It is probable that the comparison of two samples of oil by the irrationalities of their dispersion is worthy of some attention. The author is not aware of its being applied as a test; but the samples could stand side by side with respect to the illuminating source, and their spectra projected side by side could be easily observed and compared.

Although bromine and iodine exert on some of the essential oils chemically characteristic effects, it does not appear certain to what extent the action may be modified by the addition of small quantities of other oils; consequently the chemical phenomena, as well as a knowledge of their specific gravities and boiling-points, cannot be considered as offering any assistance to the detection of accidental or intentional impurities when existing in small quantities.

The process which the author submitted is one which has given great satisfaction in all the experiments which he has made, and was suggested by a discovery due to M. Rousseau, quoted by De la Rive, "that olive-oil, when mixed with $\frac{1}{100}$ part its volume of oil of poppies, increased the number of vibrations of a magnetic needle in a given time, when the same was included or made to form part of a voltaic circuit." This isolated fact would be of service for the determination of the purity of olive-oil, if oil of poppies were the only sophisticating ingredient.

The adulterants of the volatile oils are principally turpentine and alcohol †.

Compared with any of the essential oils, turpentine has an immense resistance, whilst that of alcohol is enormously lower than any of them, except perhaps that of oil of bitter almonds, which is so low that he did not measure it.

The importance of this general fact is at once apparent, since the addition either of alcohol or turpentine in the smallest quantity is readily detected; and the quantity denoted by the variation in the deflection, either when compared with a standard of known purity, or by the resistances themselves.

The oils of lemon and bergamot, when mixed with a small proportion of turpentine, do not, however, show such marked differences as the generality of the essential oils.

The addition of turpentine to oil of lavender is more strongly marked by this test than in any other case.

The effects produced by mixing different specimens of the same oil together are

* Published *in extenso* in the 'Chemical News' for Sept. 20, 1867.

† The foreign oils are no doubt sometimes entirely substituted for the English oils, or largely diluted with them,

also perceptible; thus the German oils of peppermint, or foreign samples of lavender-oil, produce modifications in the electrolysis.

The bleached oils have even a lower conducting power than the unbleached oils; and in this respect olive-oil possesses a greater difference than almond-oil. It is not easy to explain this.

A singular difference exists between the Italian and the East Indian castor-oils. This difference will enable one to detect a very small percentage of the one added to the other.

Cotton-seed-oil and oil of poppy, as well as turpentine, are so rapidly altered in their conducting power by electrolysis, that there is not the slightest difficulty in recognizing them in samples of oil.

Olive-oil, when free from cotton-seed-oil or oil of poppy, has its resistance increased by electrification; but if the smallest quantity of either of them exist in a sample of olive-oil, it produces a contrary effect by a prolonged contact with the battery.

These results of electrolysis are alone important in determining the condition of a sample of olive-oil.

On a New Manufacturing Process for the Perpetual Regeneration of the Oxide of Manganese used in the Manufacture of Chlorine. By Walter Weldon.

Every process, previous to that to be described in the present paper, by which it has been attempted to regenerate oxide of manganese from the residues of the manufacture of chlorine, has been performed in the dry way, and has thus required considerable time, and has involved not only at least one—more or less troublesome and costly—furnace operation, but also several removals of the material from vessel to vessel and from place to place, every such removal of course entailing more or less loss of material. The process, however, which is about to be described is performed in the wet way, and may be completed, even when operating on the largest scale, within as little as one hour. Moreover, all the operations of the process are performed in the same vessel as that in which the oxide produced by it is afterwards employed to react with hydrochloric acid, and from this vessel or still the manganese is never removed, so that it is entirely free from risk of loss by removal; and as it is not subject to any other cause of loss, a charge of manganese, once put into a still, when treated by this process, not only never needs to be replaced, but never needs even to be added to, while it will liberate an equivalent of chlorine every few hours for literally any length of time. The starting-point of any process for the regeneration of the oxide of manganese employed in the manufacture of chlorine, must of course be that residue which is known as "still-liquor" being that which remains in the stills when oxide of manganese and hydrochloric acid have been digested together until all the chlorine which the oxide is capable of liberating from the acid has been liberated and given off. When working with a native oxide of manganese, the still-liquor contains, in addition to a quantity of protochloride of manganese equivalent to the quantity of oxide of manganese which has been dissolved, a considerable quantity of free acid, and more or less chlorides of iron and other bases, due to the native oxide of manganese being always more or less associated with other oxides. When working, however, with the artificial oxide of manganese produced as is about to be described, the still-liquor contains scarcely anything whatever but protochloride of manganese; and the new process consists simply in first adding an equivalent of lime to this liquor, without removing the liquor from the still, and then blowing atmospheric air through the resulting mixture of protoxide of manganese and solution of chloride of calcium. The white protoxide is thereby rapidly converted into a very dark-coloured higher oxide; and when this product has been allowed to subside from the solution of the chloride of calcium in which it was formed, and the greater part of that solution has then been drawn off from it, it is ready to be treated with hydrochloric acid, from which it then liberates chlorine, with reproduction of exactly as much protochloride of manganese as was commenced with. From this point the very simple series of operations described is repeated just as before, and so on, over and over again, for any required number of times. The manganese is

thus constantly undergoing, always in one and the same vessel, a round of regularly recurring changes of state of combination, by which it passes, first from the state of protochloride to that of protoxide, next from the state of protoxide to that of a higher oxide, capable of liberating chlorine from hydrochloric acid, then back again to the state of protochloride, and so on continually.

GEOLOGY.

Address by the President, Archibald Geikie, *F.R.S., F.G.S.*

Among the Lower Silurian, the oldest recognizable volcanic rocks in this country, two principal epochs of eruption have been detected by Professor Ramsay and his colleagues of the Geological Survey. One of these occurred during the deposition of the Llandeilo rocks, and is indicated by the igneous rocks of Aran Mowddwy, Cader Idris, Arenig, and Moelwyn; the other is marked by those of the Snowdon district, which lie among the Bala beds. These volcanic rocks consist partly of massive sheets of felstone, varying in texture and colour, and partly of thick accumulations of tuff or ash. The former are true lava-flows, the latter point to frequent showers of volcanic dust, and to the settling of such dust and stones on the sea-bottom, where they mingled with the ordinary sediment, and with shells, corals and other organisms. Some of these ashy deposits attain a great thickness. Thus, at Cader Idris, they are about 2500 feet thick, the accumulated result of many eruptions. Northwards this mass thins entirely away, and the ordinary sedimentary strata take its place. Equally local are the massive beds of felstone which represent the submarine lava-flows of the time. Sometimes they still preserve the slaggy vesicular character which marked their surface when the melted rock was in a state of motion along the sea-bottom—an evidence of the existence and position of true submarine volcanoes during the Lower Silurian period in Wales. In the lake district, similar proofs of volcanic action have been found among the lower Silurian rocks of that region. In Scotland, no very distinct traces of volcanic activity have yet been detected among rocks of the lower Silurian age. In the Lower Silurian rocks of the south-west of Ireland, beds of ash and felstone are interstratified, resembling in general character and mode of occurrence those of Wales. In Wales, volcanic action does not appear to have outlasted the Lower Silurian period; but in Ireland, among the headlands of Kerry, massive sheets of ash are intercalated in grits and slates, which, from their fossils, have been assigned to the age of the Wenlock series.

The Old Red Sandstone of the southern half of Scotland abounds in igneous rocks, from the base of the series to the top. In its lower band lie the chains of the Sidlaw and Ochil Hills, and many detached masses scattered over the lowlands along the southern flank of the Grampians. These are composed of different felstones and porphyrites, with interbedded sheets of tuff, trappean conglomerate, and sandstone, stretching in the Ochil and Sidlaw range for sixty or seventy miles, and rising here and there to heights of 2000 feet above the level of the sea. This group of hills contains some of the thickest masses of trappean rock in the country. In what seems to be a middle portion of the formation comes the group of the Pentland Hills, consisting of long massive beds of trap, like the different varieties in the Ochils, with intercalations of tuff, conglomerate, and sandstone, the whole reaching a thickness of fully 5000 feet. In Ireland also the Old Red Sandstone furnishes evidence of active volcanic vents. Nor are traces of volcanic activity wanting in England during the same great geological period. In Cornwall and South Devon frequent proofs have been recognized of contemporaneous igneous action among the limestones and slates of the Middle Devonian series, and thence through the Upper Devonian into the lower part of the Carboniferous group. These consist in frequent bands of trappean ash, and of crystalline amygdaloidal and vesicular greenstone or other trap. The ash passes by insensible degrees into the

ordinary sedimentary strata of the series, sometimes containing fossils, and in certain places so interlaced with bands of limestone as to have been quarried for lime.

The base of the Carboniferous series in Cornwall and South Devon is marked by the occurrence of ash and crystalline amygdaloidal greenstone similar to the igneous masses in the neighbouring Devonian rocks. In the centre of England the well-known toad-stones of Derbyshire indicate intermittent volcanic activity during the formation of the carboniferous limestone. They consist of three principal beds of trap, averaging each about 60 or 70 feet in thickness, preserving their course for many miles between the strata of limestone, probably, as pointed out by Mr. Jukes, the result not merely of one eruption, but rather of different flows from distinct vents, and uniting into one sheet along a common floor. Passing into Scotland, we find the carboniferous formation of the broad midland valley full of the most striking evidences of volcanic activity. In the west, great sheets of different porphyrites, with interbedded tuffs, sandstones and conglomerates, lie in the lower part of the formation, and rising in broad masses bed above bed, form that conspicuous chain of terraced heights which stretches from near Stirling through the range of the Campsie, Kilpatrick, and Renfrewshire hills, to the banks of the Irvine in Ayrshire, and thence westward by the Cumbrae Islands and Bute, to the south of Arran. In the eastern districts, instead of such widespread sheets of volcanic rock, the Carboniferous series includes hundreds of minor patches of tuff, dolerite, basalt, and porphyrite. The area of the Lothians and Fife seems to have been dotted over with innumerable little volcanic vents, breaking out and then disappearing one after another during the lapse of the Carboniferous period up to at least the close of the carboniferous limestone. The very limited area occupied by the erupted material is often remarkable. A mass of ash 100 feet thick or more may be found intercalated between certain strata, yet at a distance of a mile or two the same strata may show no trace of any volcanic material. Nowhere is this feature more wonderfully exhibited than in the coal-field of Dalry in the northern part of Ayrshire. The black-band ironstone of that district appears to have been deposited in hollows between mounds and cones of volcanic tuff, sometimes 600 feet high, round and over which the later members of the Lower Carboniferous formation were deposited. Hence the shafts of the pits are sometimes sunk for 100 fathoms through the tuff; and at that depth mines are driven horizontally through the volcanic rocks to reach the ironstone beyond. The great carboniferous limestone series of Ireland contains evidence that here and there, at various intervals during its formation, minor volcanic vents were active on different parts of the sea-bottom.

Among the Permian sandstones of the south-west of Scotland there occur some interesting proofs of contemporaneous volcanic action. In Nithsdale, and still more conspicuously in the centre of the Ayrshire coal-field, these sandstones contain towards their base a thick group of dark reddish-brown amygdaloidal porphyrites and tuffs. Connected with these rocks are numerous bosses of a coarse volcanic agglomerate, which descend vertically through the coal-measures, altering the coal. They are the "necks" or orifices from which was ejected the volcanic material which now forms a conspicuous range of rising grounds overlying the heart of the coal-basin of Ayrshire.

The New Red Sandstone series of Devonshire, in the neighbourhood of Exeter, furnishes clear proofs of volcanic activity. Sheets of a dark reddish-brown felspathic rock, sometimes compact or porphyritic, but usually of scoriaceous character, are intercalated among the lower parts of the Red Sandstone series of that neighbourhood. Sir Henry De la Beche, who described these igneous rocks many years ago, noticed that the more compact portions, instead of extending horizontally as beds among the sedimentary strata, descend vertically through them, as if these detached parts marked the site of some of the orifices whence the melted lava was rupted.

The series of successive volcanic phenomena, which may thus be traced through the palæozoic rocks of the British Islands up to the New Red Sandstone, is now abruptly broken. I am not aware of any satisfactory proofs of contemporaneous volcanic rocks among the secondary rocks of Britain, save in the Red Sandstone of Devonshire just referred to. Following a suggestion of Prof. Edward Forbes, I formerly regarded the great trappean masses of Skye and the other western islands

as probably of Oolitic age. But more recent investigations in Antrim, Mull, and Eigg, have convinced me that in these districts, and probably also in Skye, the great basaltic plateaux which form so conspicuous a feature in the scenery of our north-western sea-board, date from tertiary times. From Antrim northwards through the inner Hebrides and the Faroe Islands to Iceland there is a broken chain of volcanic masses, part, and not improbably the whole, of which are of Miocene age. In Ireland sheets of dolerite and basalt, in all 500 or 600 feet thick and some 1200 square miles in extent, repose directly upon an eroded surface of chalk. In Mull, similar plateaux, overlaid with masses of porphyrite and trachyte-like rocks, attain a united thickness of more than 3000 feet, yet at their base they contain recognizable plants of Miocene species. This vast depth of old lavas and tuffs points to a lengthened continuance of volcanic activity along the north-western margin of our country—an activity, however, marked by prolonged periods of repose, as the Scuir of Eigg and the coal and shales of Mull sufficiently prove. These masses, vast though they be, are by no means the only, if they are indeed the chief, relics of Tertiary volcanic action in Britain. If, starting from the basaltic plateaux of the north of Ireland or of the inner Hebrides, we advance towards the south-east, we soon observe that an endless number of trap-dykes, striking from these plateaux, extends in a south-easterly direction athwart our island. The south-western half of Scotland and the northern parts of England are, so to speak, ribbed across with thousands of dykes. These are most numerous near the main mass of igneous rock, whence they become fewer as they recede towards the North Sea. Usually a dyke cannot be traced far. In Berwickshire and the Lothians, these E. and W. or N.W. and S.E. dykes, often less than half a mile long, are well shown; in Ayrshire they become still more numerous, traversing the coal-field and altering the coal-seams; in Arran and Cantyre their number still increases, until, after a wonderful profusion of them in Islay and Jura, they reach the great volcanic chain of the inner Hebrides. From their manifest intimate connexion with that chain, from the fact that they cut through all the formations they encounter up to and including the chalk, and that they cross faults of every size that may lie in their way, I regard these dykes as of tertiary age. If this inference is sustained, as I have little doubt it will be, by a more detailed investigation of the north-western districts, it presents us with striking evidence of the powerful activity and wide range of the volcanic forces in our country during the Miocene period. With these dykes, and the Tertiary igneous masses from which they proceed, the record of volcanic action in Britain appears to close.

Let me now allude to one or two portions of this broad subject which seem to me worthy of special notice. One of the first features to arrest attention is the singular persistence of volcanic phenomena in a limited area. Take, as an illustration, the neighbourhood of Edinburgh within a radius of ten miles from the town. First and oldest comes the long range of the Pentland and Braid hills, consisting of a mass of bedded igneous rocks in a middle series of the Old Red Sandstone. These old lavas reach a thickness of 4000 or 5000 feet. Next in chronological order are the Calton Hill and lower portion of Arthur's Seat, which mark the continuance of volcanic action into the Lower Carboniferous period. The carboniferous rocks for miles around these hills are full of the traces of contemporaneous volcanoes, sometimes in the form of sheets of tuff marking the occurrence of little detached tuff-cones, sometimes in wider areas of tuff, basalt, and dolerite, where a group of minor volcanic vents threw out showers of ash and streams of lava. To the east rise the isolated Garlton Hills, which date from before the carboniferous limestone; westwards, scores of little basaltic crags and rounded tuff-hills mark out the lower carboniferous volcanoes of Linlithgowshire. To the north, the endless crags, hills and hillocks of the Fife coast contain the record of many eruptions from the middle of the calciferous sandstones high up into the carboniferous limestone group. Even the coal-measures of that county are pierced with intrusive bosses of trappean agglomerate, which indicate the position of volcanic vents, possibly of Permian age. The same or a more recent date must be assigned to the later unconformable agglomerate and basalt of Arthur's Seat. Nor is this the whole. Latest of all come innumerable trap-dykes, running with a prevalent east

and west trend, and cutting through all the other rocks. Here, then, in this little tract, about the size of a small English county, there are the chronicles of a long series of volcanic eruptions, beginning in the middle of the Old Red Sandstone, and coming down to a time relatively so near our own as that of the Miocene rocks. Nor is this by any means an exceptional district. Illustrations of a similar persistence of volcanic action may be gathered in many other tracts of equally limited extent.

Another fact which a general survey of the character of our volcanic rocks soon brings before us, is that, as a whole, those of earlier date differ distinctively in composition from those of more recent origin. From the first traces of volcanic activity in this country up to about the close of the Old Red Sandstone or beginning of the Carboniferous series, the interbedded (*i.e.* contemporaneous) igneous rocks consist for the most part of highly felspathic masses, to which the names of clinkstone, claystone, compact felspar, porphyry, hornstone, felstone, &c. have been given. On the other hand, from the upper part of the Old Red Sandstone, or the lower members of the Carboniferous series, up to the end of the long history, the erupted masses are chiefly augitic, as basalts and dolerites (or greenstones, as the latter have been usually termed in Scotland). Were these rocks subjected to further and more detailed chemical examination, additional knowledge might possibly be acquired respecting the history of the changes which have taken place within the crust of the earth. As geologists, it is important to note that, though two classes of volcanic rocks can thus be determined by analysis of their composition, no broad essential distinctions appear to be traceable in their mode of occurrence. Certain minor differences are, indeed, readily observable, such as the greater thickness of the beds among the older rocks, and the more frequent occurrence of columnar structure among the newer. Perhaps these and other distinctions may eventually give us a general type for each class. Nevertheless, in its broader features there would seem to have been a striking uniformity in volcanic action from the earliest times down to our own day.

This leads me to remark that a study of the igneous rocks of Britain furnishes no proofs that volcanic action has been slowly diminishing in intensity during past geological time. The amount of volcanic material preserved in our Old Red Sandstone group probably exceeds that of our Silurian system, even after all due allowance for the greater denudation of the older series. The number of distinct volcanic centres traceable among the Carboniferous rocks in like manner surpasses that of the earlier formations. But by much the most extensive mass of volcanic material in these islands belongs to the latest epoch of eruption—that of the Miocene period. In one mountain alone, Ben More, in Mull, these youngest lavas rise over each other, tier above tier, to a height of more than 3000 feet; yet their base is concealed under the sea, and their top has been removed by denudation. We have here, therefore, no proof of a slow diminution of volcanic activity. The period separating the Miocene basalts from the New Red Sandstone trap-rocks, which seem to come next to them in point of recentness, was immensely vaster than that which has elapsed between the Miocene basalts and the present time. There is thus no improbability in the eventual outbreak once more of the subterranean forces. Nay, further, were a renewed series of volcanic eruptions to take place now, they might in the far distant future be thrown together with those of Miocene date, as proofs of one long period of interrupted volcanic activity, just as we now group the igneous rocks of the Lower Silurian, or of any other geological formation: so near to us, in a geological sense, are those latest and grandest of our volcanic phenomena.

Among the different forms assumed by our igneous rocks, one of the most interesting, and, at the same time, most full of difficulty, is that of the trap-dykes. To my own mind there are few parts of the geology of the country so hard to understand as the extravasation of the thousands of dykes by which the north-western portion of this island is so completely traversed. For the reasons already assigned, I would refer the leading system of these dykes to the same geological age as the Tertiary volcanic rocks of the north-west. Yet we find them rising to the surface, and extending for leagues, to a distance of fully 200 miles from the nearest point of the basaltic plateaux. Did they reach the surface originally? If

so, were they connected with outflows of dolerite, now wholly removed by denudation? I confess that this supposition has often presented itself to me as carrying with it much probability. It seems to me unlikely that so many thousands of dykes should have risen so high as the present surface, retaining there (as shown by deep mines) much the same proportions as they show many fathoms down, and yet that none of them should have reached the surface which existed at the time of eruption. I regard it as much more probable that some of them, at least, rose to daylight, and flowed out as *coulées,* even over parts of the south of Scotland and north of England, where all trace of such surface-masses has long been removed. Some of the surface-masses of dolerite in these districts may indeed be of Tertiary age; yet the proofs which the great Miocene basaltic plateaux present of enormous denudation are so striking as to make the total disappearance of even wide and deep lava-currents quite conceivable. But a much more serious difficulty remains. These dykes, as a rule, do not come up along lines of fault, yet they preserve wonderfully straight courses, even across fractured and irregular strata. Each dyke retains, as a rule, a tolerably uniform breadth, and its sides are sharply defined, as if a clean, straight fissure had been widened and filled up with solid rock. In the coal-mines of Ayrshire, for instance, the miners have driven through the dyke and found the coal, altered indeed, but at the same level, at the other side. More than this, the dykes are found cutting across large faults without any deflection or alteration. In short, no kind of geological structure, no change in the nature of the rocks traversed, seems to make any difference in the dykes. These run on in their straight and approximately parallel courses over hill and valley for miles. The larger faults of this country tend to take a north-easterly trend, and correspond in a general way with the strike of the formations. At right angles, or more or less obliquely to these, are numerous faults of lesser magnitude, which follow roughly the dip of the rocks. But though these different systems of fissures already existed, and, as we might suppose, would have served as natural pathways for the escape of the subterranean melted rock towards the surface, the latter rose through a new series of fractures, often running side by side with those of older date. How were these new fractures produced? and how is it that they should run through all formations, up to and including the older parts of the Miocene basalts, not as faults, with a throw on one side, but as clean, straight fissures, with the strata at the same level on each side? I do not pretend to answer these questions. Let me only remark that, had the trap-rock been itself the disrupting agent, it would have risen through the older fractures which already existed as the planes of least resistance. The new fissures must be assigned to some far more general force, of the action of which the trap itself furnishes perhaps additional evidence.

Another feature of our igneous rocks deserving more special consideration is the occurrence among them of true vents, or the sites of volcanic orifices. A very considerable number of these vents is filled up with a coarse agglomerate, consisting of fragments of different trap-rocks, with pieces of the surrounding sedimentary strata. Such vents are sometimes not larger than a dining-table. In many cases, where the material filling them is fine in texture, it is well stratified; but its beds are on end, or thrown into different inclined positions. The strata around them are much indurated, and frequently, perhaps usually, are bent sharply down round the margin of the vent, as if the ash or agglomerate, from contraction or otherwise, had sunk and pulled the adhering strata down with it. Instructive sections of these rocks abound along the coast line of Fife and East Lothian, and they occur likewise in Ayrshire. One other part of the subject may be alluded to as deserving of inquiry. There seem to be indications that local but well-marked metamorphism and the extravasation of syenitic and granitic rocks have taken place in connexion with some of our most recent volcanic phenomena. In Skye, Mull, and Arran the association of such crystalline rocks with sheets or dykes of dolerite and basalt should be worked out carefully. The volcanic rocks of Britain are now brought under the notice of the Section with the view of indicating a field of research where much remains to be discovered, and where the labourers are but few. As a result of the neglect into which it has fallen, the nomenclature of this portion of British geology has been virtually at a stand for about half a century.

While so much has been done in this respect by chemists and geologists abroad, we are but little further forward than when the great outlines of the subject were sketched long ago by the early leaders in the science. The same vague names, the same confused and defective arrangement, the same absence of careful chemical and mineralogical analysis, so excusable in the infancy of the science, still disfigure our geological writings and even the best of our geological collections. Field-geologists must be content to bear their share of the blame; yet it is not from their hands that the needed reform is mainly to be looked for. They can do but little till chemistry comes to their aid with information regarding the composition of the rocks which they investigate, and the extent to which the nomenclature adopted in other countries can be applied in their own. Surely the time must come ere long when it will be deemed a task worthy of years of long and patient research to work out the nature and history of the volcanic rocks of this country. Such a task will not be the work of a single observer. It will require the labour of the geologist, skilled to glean the data that can only be gathered in the field, and of the chemist who, aided and guided by these observations, shall seek to determine the composition of the different igneous rocks, and the relation which, in this respect, they bear to the rocks of other regions, and to the products of modern volcanoes. But whether distant or near, the day will doubtless arrive when we shall be able to connect into one story, as far at least as our fragmentary records will permit, the narrative of the varied volcanic eruptions which from early geological times have taken place in the British Islands, and to link that chronicle with the long history of volcanic action over the globe.

The passage of Schists into Granite in the Island of Corsica.
By D. T. ANSTED, *M.A., F.R.S.*

The object of this communication was to advocate the view that granite is a metamorphic rock, and not in any sense primitive or the nucleus of the earth. A section was described, the result of observations recently made, taken on the side of a road recently made between Ile Rousse and S. Florent, on the north-western side of the island. The section presented unmistakeable and numerous alternations of compact, well-crystallized, whitish-grey granite, with argillaceous rock, schists, grits, and rotten granite. The dip of the various beds varies from 30° to 10°, diminishing towards the north; the thickness of the beds is often several yards, but not very great. There is much granite near, towards the interior of the country, and stratified rocks near the coast. The general inference of the author from this section was, that granites are not erupted but metamorphic rocks.

On the Lagoons of Corsica. By D. T. ANSTED, *M.A., F.R.S.*

The eastern coast of Corsica, though now the most malarious district in the Mediterranean, was inhabited and healthy 2000 years ago; and there is good historical evidence that it continued healthy till the end of the fifteenth century. Remains of two cities are still to be traced on these plains, which are now absolutely deserted. Each town was situated at the southern extremity of a large existing lagoon, near a principal river, provided in each case with a delta. Beyond each river, to the north, are numerous small torrents, originally entering the sea, but now feeding the lagoons, which have been formed by the sands of the delta drifted northwards from one river delta to the next beyond, owing to the prevalent winds. The drainage of the torrents is received into and supplies the lagoons. During summer there is no water brought down, and a sand-bar has accumulated until it has become a bank. In winter, the waters brought down are driven towards the northern and open end to escape, but they leave behind a large quantity of organic matter which during the subsequent heats of summer rots, and becomes converted into miasma. So long as the communication was open from the torrents to the sea the coast was healthy, but so soon as the lagoon was formed the malaria set in.

The largest of the lagoons is that of Biguglia, extending from the delta of the Golo nearly eight miles towards the north. Its greatest width is 3000 yards, diminishing first to 2000 for a long distance, and then to 1000. About a mile

from the northern extremity it becomes a mere passage for the surplus water, about eighty yards wide, terminating in a narrow opening to the sea, liable to be choked up. It is separated from the sea by a sand-bank, at first 900 yards wide, diminishing to 300 yards. This is generally high enough to keep out the highest storm-waters; but there are remains of two old cuts through which the sea enters occasionally. The area of the lagoon is 4800 acres; the depth averages five or six feet below the mean level of the Mediterranean. Besides a large number of winter torrents, there is one river emptying into the lagoon. The area supplying the torrents is about 20,000 acres, and that feeding the river and torrents to the north of it, about 25,000 acres. The mean annual rainfall of the district is estimated (from three years' observations) at twenty-four inches, of which ten inches fall in October and November, which is the rainy season.

The history of the formation of the lagoon is very clear. About 2000 years ago the bank of sand now nearly closing it did not exist. The bank must have commenced and increased gradually till about 300 years ago, when it was completed. The gradual depopulation continued for about two centuries. The bank is about seven miles long, a quarter of a mile wide, and fifteen feet high above the shallow sea-bottom outside.

There is proof of the recent closing up of the lagoon in old walls and fragments of buildings near the northern end. There is no doubt of the comparatively modern elevation of all Corsica, but this will not account for the lagoons. These are due to the drifting of the sands, as explained; and as the unhealthiness of the island (which is extreme) is due to the lagoons, it would be diminished if they were greatly reduced. The author believes that by separating the drainage areas of the lake into two parts, and removing, by pumping, the whole southern part, which is perfectly practicable, at least 4000 acres of rich land would be recovered, and the rest of the land rendered cultivable. The operation could be adopted with great facility and at small expense, and could not fail to exercise an important influence on the material prosperity of Corsica.

On the Granites and other Rocks of Ben More, from a Letter addressed to Professor Phillips. *By* His Grace *the* Duke *of* Argyll, *LL.D., F.R.S.*

When I was in the island of Mull the other day, I observed a fact which may perhaps be of some interest, which is, that Ben Craig, one of the lower shoulders of Ben More, exhibits very clearly the passage of a rock which looks like pure trap into regular granite. At the base of the shoulder mountain, which may be about 2000 feet high, it is a mass of a fine-grained compact granite. At the top it is a mass of stuff which weathers white, and has a fracture like some kinds of trap. At an intermediate elevation the trap-like stuff contains many crystals of felspar very distinctly separated. A little lower down these crystals become more frequent, and a granitiform rock appears; and very little lower the regular granite *subtervenes*. I could detect no separation. The top of the mountain is very white, the rock very shattered, some of it very light, with one or two *dykes* passing through this trap-like mass. The dykes are of a closer texture, with white crystals, wholly unlike the surrounding mass. I must add that, though this stuff breaks like a kind of trap, it is wholly unlike trap in other respects. It is perfectly amorphous, both in structure and in the mode in which it occurs. It is not laid in sheets and terraces like the traps of the same island elsewhere. In short it is not trap at all, but the matter out of which granite seems to have been made by pressure, and crystallization under pressure.

I send in a separate cover—1. The granite as it appears at the base of the hill, or two-thirds of the way up; 2, a bit showing the appearance of the felspar crystals where they appear; and 3, the rock at the top, of which a vast mass of the mountain is composed. The whole structure of Ben More in Mull is full of interest. The summit peak is of stratified rock, mica-slate; and all the lower shoulders are granite or igneous rock *becoming* granite.

Report on recent Explorations in the Gibraltar Caves.
By Capt. Fred. Brome.

The explorations recorded in this communication were conducted principally in "Martin's" and St. Michael's Caverns.

Martin's Cave opens on the eastern face of the rock, below O'Hara's Tower. It is an ancient sea-cave, though now upwards of 700 feet above the level of the Mediterranean. The excavations in this cavern were commenced on the 23rd of June, and continued till the 22nd of July. There were no traces whatever of any previous attempts at exploration. The first operation was to excavate the dark earth all along, close to the south side, which is from six to three feet in depth. At this depth the diggers came upon a stalagmite floor of varying thickness. Here, after a few hours' work, were found deposited two portions of a lower jaw, supposed to be human; about two bushels of bones of ox, goat, sheep, rabbit, &c.; several bones of birds and fish; two bushels of broken pottery of the rudest or unmarked kind, 57 pieces ornamented; 61 handles and pots; 6 stone axes and 70 flint knives; 1 excellent flint core; 20 lbs. of flint chips; 12 pieces of worked bone; a portion of an armlet and anklet; 10 lbs of sea shells, and a few land shells, together with three rounded pebbles. On the north side the same class of objects were met with, and in a small chamber on this side, under five or six feet of earth, Captain Brome's son came upon a small chamber containing two ancient swords, one partly imbedded in stalagmite, and both much injured; and on a subsequent occasion, a small enamelled copper plate was found, which appears to have had a design upon it of a bird with its bill open, in the coils of a serpent. The colours are bright, and the object is beautifully made. These interesting relics have been referred by Mr. Franks to the eleventh or twelfth centuries. Excavations were then made in a cavern, situated on the same face of the rock, but a little to the south, and at a higher level than "Martin's" Cave, and named by Captain Brome the "Fig-Tree Cave," in which similar rude works of art, consisting of fragments of pottery, flint and stone implements, &c. were found.

Captain Brome's greatest interest, however, was centred in "St. Michael's Cave," in which, day after day, numerous human remains were found, some imbedded in the stalagmite, others loose, associated with stone axes, flint chips, and flint knives of the smallest size hitherto met with in the Gibraltar caverns.

On the north side of the upper chamber in St. Michael's Cavern, on breaking up a thick stalagmite floor, a small aperture was discovered. When this had been enlarged sufficiently to admit of Captain Brome's entrance, he found a series of passages and caverns, the extreme travelling distance of which from the entrance was exactly 200 feet. There were no means of access to it, excepting by the aperture by which Captain Brome entered. The walls were snow-white, and the pillars and stalactites of the most variable and fantastic forms. Some of the latter, with the thickness only of a goose quill, were five feet long! The bearings of the cavern generally run N.W. At the south end of this cavern a perpendicular fissure was discovered, through which came a strong wind. The fissure was about nine inches wide, but one of the men (military prisoners) employed was found small enough to creep through it. He returned with a wonderful story of what he had seen. On the next day, accordingly, Captain Brome sent in one of his own sons, about twelve years old, who entirely corroborated the statements previously given, viz. that there were three caves, the first very small, and about twelve feet from the narrow entrance. At some distance further there was another, about twenty feet square, and still further, a cave as large as the upper St. Michael's first chamber. The distance travelled is 250 feet from the entrance, which, added to the distance (200 feet) travelled in the first discovered cavern, make a total of 450 feet of hitherto wholly unknown caverns in so familiar a locality as the often-visited cave of San Migael.

At the date of his last advices, Captain Brome was continuing the exploration of St. Michael's Cavern, with every prospect of further interesting discoveries. But, as he says, "his surmises, that the unexplored caves would yield the same relics as the Genista Cavern, have been verified, and the fact is nearly, if not quite established, that at a former period all the Gibraltar caverns were tenanted by a race having uniform habits of living."

On the Lower Lias, and traces of an ancient Rhætic Shore in Lincolnshire. *By* F. M. Burton.

Enumeration of British Graptolites. *By* William Carruthers, *F.L.S.*

The genus was established by Linnæus, in the first edition of his 'Systema Naturæ,' for a series of natural productions which had previously been considered to be true fossils. In the genus, as it appeared in the early editions, not a single species of the fossils to which the name is now confined was included. No alteration was introduced into the genus until the twelfth edition, when *G. scalaris* appears, which had already been figured by Linnæus in his Scanian travels. This is the true type of the family, and the only species with which Linnæus was acquainted. The single-celled graptolite, which has by every one been referred to Linnæus's *G. sagittarius*, has nothing whatever to do with the organism to which he gave this name. His species is founded on a fragment of *Lepidodendron* figured by Volkmann. To correct this error, and to make the extent of the acquaintance which Linnæus had with these fossils more obvious, it was proposed to substitute the name *G. Hisingeri* for the species, after the distinguished palæontologist who first described the species, but erroneously gave it the Linnean name. The whole of the species were included by Murchison, Portlock, and others in the original Linnean genus. New genera were introduced by Barrande, M'Coy, Hall, Salter, and the author. The various genera were then described, their different characteristics noticed, and the number of species given. A new genus, *Cyrtograpsus*, was proposed for a singular form from the Wenlock of England, of which a single species only has been observed occurring both in England and Bohemia, and which the author dedicated to the distinguished author of 'Siluria.' The netted forms which had been referred to this family had been carefully examined by the author, but he could not satisfy himself as to their affinities, and for the present must exclude them.

The author enumerated the following fifty-two species, excluding synonyms:—

Rastrites peregrinus, *Barr.*, Llandeilo.
R. Linnæi, *Barr.*, Llandeilo.
R. maximus, *sp. nov.*, Llandeilo.
R. capillaris, *sp. nov.*, Llandeilo.
Graptolithus Becki, *Barr.*, Llandeilo.
G. convolutus, *His.*, Llandeilo.
G. Halli, *Barr.*, Llandeilo.
G. Hisingeri, *Car.*, Llandeilo.
G. Nilssoni, *Barr.*, Llandeilo.
G. tenuis, *Portl.*, Llandeilo.
G. intermedium, *sp. nov.*, Llandeilo.
G. Clingani, *sp. nov.*, Llandeilo.
G. Griestonensis, *Nic.*, Caradoc.
G. Salteri, *Gein.*, Caradoc.
G. Sedgwickii, *Portl.*, Llandeilo and Caradoc.
G. priodon, *Bronn*, Llandeilo to Ludlow.
G. Flemingii, *Salt.*, Wenlock. ?
Cyrtograpsus Murchisonii, *sp. nov.*, Wenlock.
C. ? hamatus (*Bail.*), Caradoc.
Didymograpsus bryonoides, *Hall*, Llandeilo,
D. Forchhammeri, *Gein.*, Llandeilo.
D. elegans, *sp. nov.*, Llandeilo.
D. geminus, *His.*, Llandeilo.
D. hirundo, *Salt.*, Llandeilo.
D. Moffatensis, *Car.*, Llandeilo.
D. Murchisonii, *Beck*, Llandeilo.
D. septans, *Hall*, Llandeilo.
D. caduceus, *Salt.*, Caradoc.
Dichograpsus aranea, *Salt.*, Llandeilo.
D. Sedgwickii, *Salt.*, Llandeilo.
D. crucialis, *Salt.*, Llandeilo.
Cladograpsus linearis, *Car.*, Llandeilo.
C. gracilis (*Hall*), Llandeilo.
Dendrograptus furcatula, *Salt.*, Llandeilo.
D. lentus, *sp. nov.*, Caradoc.
Diplograpsus acuminatus, *Nich.*, Llandeilo.
D. barbatulus, *Salt.*, Llandeilo.
D. cometa, *Gein.*, Llandeilo.
D. folium, *His.*, Llandeilo.
D. mucronatus, *Hall*, Llandeilo.
D. pennatus, *Harkn.*, Llandeilo.
D. pristis, *His.*, Llandeilo.
D. tricornis, *Car.*, Llandeilo.
D. Whitfieldi, *Hall*, Llandeilo.
Climacograptus bicornis, *Hall*, Llandeilo.
C. bullatus, (*Salt.*), Caradoc.
C. scalaris (*Linn.*), *Hall*, Llandeilo and Caradoc.
Retiolites Geinitzianus, *Barr.*, Wenlock.
R. venosus, *Hall*, Wenlock.
Dicranograptus ramosus, *Hall*, Llandeilo.
D. Clingani, *sp. nov.*, Llandeilo.
Phyllograptus angustifolius, *Hall*, Llandeilo.

On Calamiteæ and Fossil Equisetaceæ.
By WILLIAM CARRUTHERS, *F.L.S., F.G.S.*

After describing the structure of the recent *Equisetaceæ*, the author gave an account of the internal structure of the various fossil stems which had been referred to this family. True *Equisetaceæ* were rare as fossils, and the stems of *Calamites* were very unlike anything known among living acotyledonous plants. The most important characters were obtained by botanists from the fructification. The author had obtained, through the kindness of Dr. Hooker, sections of vegetable structures prepared by Mr. Binney, whose extensive acquaintance with coal-plants was well known. In some of these he had discovered fruits which belonged to *Calamites* so beautifully preserved that the most minute details could be determined, and with the help of his diagrams he described their structure, and illustrated the various points in which they agreed with, and differed from, the fruits of *Equisetaceæ*. He then described the foliage which had been found connected with *Calamites*, and which had been named *Asterophyllites*; and he showed that as similar fruits had been found associated with *Annularia* and *Sphenophyllum*, which differed from *Asterophyllites* only in the amount of cellular tissue spread out on the veins, there could be no doubt that these also were the foliage of members of this large genus or tribe of plants.

Notice of an "Esker" at St. Fort. By ROBERT CHAMBERS, *LL.D., F.R.S.E.*

On the Geology of North Formosa. By DR. COLLINGWOOD, *M.A., F.L.S.*

The author presented a geological section, made by himself, across the north part of the island of Formosa, from Tam-sug in the west, to Pe-ton Point in the east. The neighbourhood of Tam-sug was remarkable for an abundant collection of angular and rounded boulders, imbedded in a thick deposit of alluvium. Further west calcareous grit prevailed, rising into hills, where the strata cropped out at an angle of 15° to the north-east. Among these hills sulphur springs were found, in which the sulphur issued in a sublimed state with jets of steam from crevices in the rocks. On the north-eastern side of the island Red Sandstone rocks prevailed, having the same inclination, and among them were situated the coal deposits, which rendered Kelung an important harbour.

On the Geology of the Islands round the North of Formosa.
By DR. COLLINGWOOD, *M.A., F.L.S.*

The author described the geological structure of several small islands which he had visited, including the Pescadores (or Ponghou archipelago), which presented some remarkable basaltic formations, resembling in character the Antrim coast. Haitan islands, on the Chinese coast, composed of whinstone trap, granite, and other volcanic rocks; also two small groups of islands north-east of Formosa, seldom visited, consisting of Craig, Pinnach, and Agincourt islands, and Hoa-pin-su, Tia-usu, Pinnacle Rock, and Raleigh Rock, respectively. The complicated structure of some of these islands was described by the aid of diagrams.

Notes on the relation of the Glacial Shell Beds of the Carse of Gowrie to those of the West of Scotland. By the REV. W. H. CROSSKEY.

On the Calamine Deposits of Sardinia.
By F. GORDON DAVIS, *Mining Engineer.*

The deposits of calamine are invariably situated in Silurian limestone, on or near the summit of a mountain, and often forming the saddle between two high peaks. The direction they take (with only two exceptions) is north and south, parallel to the strike of the limestone, and connected with north and south lead lodes, though not often actually in their run. The deposits vary from five to twenty-five fathoms in width, and fifty to eighty fathoms in length; sometimes several deposits are situated in a line, and thus form runs of ore ground 250 to 300

fathoms in length. The depth to which these deposits extend has not yet been ascertained. At Monte Poni mine calamine forms the cap of the rich lead deposit.

The ore is a mixture of the silicate and carbonate of zinc.

The author considers that the deposits are being worked in too reckless a manner.

On some Mammalian Remains from the submerged Forest in Barnstaple Bay, Devonshire. By HENRY S. ELLIS, *F.R.A.S.*

The author exhibited a collection of bones, teeth, charcoal, masses of oyster and cockle shells, flint flakes and cores, unbroken flints, masses of peat and clay, broken pebbles, and specimens of bog-oak and other trees, found by him in a certain part of the submerged forest in Barnstaple Bay; also a part of a stake of the row referred to in the paper. The paper was illustrated by a map and sections.

The submerged forest is situated outside the Northam Pebble Ridge, and is of considerable extent; but the bones, flint flakes, charcoal, and shells have as yet been found in a spot (only a few yards square) at the northern end of it, at a distance of about 200 yards from the Pebble Ridge, and about 300 yards from the newly-erected baths.

The author states that during the last few years patches of clay and peat have become exposed on the surface of the previously smooth sandy beach of Northam —that whilst on a visit to the adjacent newly-built watering place, Westward Ho, in the summer of 1866, he discovered large quantities of flint flakes underneath some of the patches referred to—that in the summer of this year (1867) he found, near the same spot, the bones, teeth, charcoal, &c. exhibited to the Section.

The author's diagram showed that the patches of clay and peat were laid bare, and stood eight or nine inches above the level of the sand, and at about that depth the flint flakes are found imbedded in the clay; that the bones, teeth, and charcoal are in some places mixed with them, but generally underlie them, and that the large masses of cockle-shells and comminuted oyster-shells lie underneath the whole.

Some of the bones and teeth have been examined by an eminent comparative anatomist, who pronounces most of them to be those of *Cervus elaphus*, and suggests that a fragment of one of them belonged to some bird. The bones are, for the most part, in good condition, having sharp fractures, and some of them appear not to have lost their animal matter. The flint flakes and cores are generally admitted to be remarkably good specimens of the well-known type described by Sir John Lubbock, as those of the first stone period. The flakes vary in length from half an inch to two inches (those found in the peaty clay are purple, but those from near the masses of cockle- and oyster-shells are opaque-white). All have very keen edges, and are not serrated, a fact which doubtless arises from each flake being separately imbedded in clay. Some of the patches of peaty clay contain roots and prostrate branches of trees, and others leaves of a large *Iris*, in perfect condition, only faded in colour. The common yellow *Iris*, or flag (*Iris pseudo-acorus*) grows luxuriantly in the immediate neighbourhood.

The author mentions that deers' antlers have been occasionally dredged up in the bay, and quotes a local tradition that the oak-trees used for the roof and seats of the church of Braunton (which is situated on the northern edge of the delta of the Taw) grew in a forest which formerly occupied the site of the Northam Burrows, and that the trees, when felled, were drawn to the church by reindeer. A species of red deer still exists in its wild state on Exmoor.

The author submits that the collection is of interest on account of the various objects, in such a good state of preservation, having been found associated together in a locality which is covered by the sea at every tide to a depth of at least twelve feet, and at so great a distance from the present boundary of dry land. He admits that the burial of the bones in peaty clay underneath sand would naturally tend to their long preservation and protection; but he thinks the general belief of the parishioners of Northam, that the sea is constantly and rapidly encroaching on the land, is worthy of much consideration in forming an estimate of the remoteness of the period when man left those interesting indications of his existence.

Notes on the Perseberg Iron Mines, Sweden. *By* C. Le Neve Foster, *B.A., D.Sc., F.G.S.*

These mines are situated near the town of Philipstad. The ore, which is magnetite, occurs in the form of more or less thick deposits, parallel to the bedding of the surrounding rock. The rock, or "country," is *hälleflinta*, which is regarded by Swedish geologists as a very fine-grained gneiss. In the immediate neighbourhood of the ore, however, the "country" consists of a rock made up of garnet, hornblende, epidote, and varieties of augite: limestone is sometimes present. The author then compared these Swedish deposits with some very small beds of magnetic iron ore found in the Crown's Rock, Botallack Mine, St. Just, Cornwall. The magnetite occurs here under very similar conditions. Both deposits were considered to have existed originally in the form of beds in sedimentary rocks, like the Cleveland iron ore for instance, and to have been since metamorphosed; the fact that the ore is accompanied by garnet, hornblende, &c., is explained by the supposition that it was the ore that furnished the iron which enters into the composition of these minerals.

An Account of the Progress of the Geological Survey of Scotland. *By* A. Geikie, *F.R.S.*

The author showed the mode in which the survey is carried on, describing particularly the manner of filling in the geological features of each district of the country on the Ordnance Survey Maps. Upwards of 3000 square miles altogether have already been surveyed. Hitherto the work has been kept back by the smallness of the staff and the backward state of the Ordnance Survey; but the staff has now been largely increased, and as the Ordnance Survey Maps of the whole of the south of Scotland are now ready, the work will be much more rapidly proceeded with. The area geologically surveyed includes the district from the mouth of the Tay to Berwick on Tweed, and from the eastern end of Strathearn to the sources of the Tweed; also portions of the counties of Ayr, Wigtown, Kirkcudbright, Lanark, and Renfrew. Five sheets of the one-inch map have been published, and others are in preparation. Maps on the scale of six inches to one mile have been issued for the coal-fields of Edinburgh, Haddington, and Fife, and others for the Ayrshire coal-field are engraving. Two sheets of horizontal sections across Edinburghshire and Haddingtonshire have been published; also one sheet of vertical sections of the Edinburgh coal-field. Three memoirs, descriptive of Sheets 32, 33, and 34 of the one-inch map have appeared. Large collections of fossils and rock-specimens have been made in the course of the survey.

On Tertiary and Quaternary Deposits in the Eastern Counties, with reference to Periodic Oscillations of Level and Climate. *By the* Rev. J. Gunn, *M.A., F.G.S.*

The author stated that periodic changes in the level of land and water and of climature had been assigned by men of science to astronomical causes; and that under the impression that if such were the fact, the effects of such periodic changes might still be traceable, he had examined the Tertiary strata in the Eastern Counties.

He specified and described at length three several oscillations of level from the period of the forest-bed to the termination of the glacial epoch; and after pointing out advantages in many respects derived from thus tracing the sequence of strata, he expressed a hope that others might be led to make a similar inquiry in older beds, so as to ascertain whether the supposed relation between astronomical and geological cycles holds good or not.

The author was of opinion that, considering the length of time that had elapsed since the commencement of historical evidence, during which scarcely any geological change was perceptible, the precessional cycle was too short, and that such changes must be referred to a longer cycle, to which the precessional was subordinate; and he further indulged in the hope that, if the length of the cycle were ascertained, and the numbers of such oscillations counted, supposing, of course, that

the relation between the two were established, an approximation could be made to the age of certain portions of the crust of the earth.

On the Coniston Group of the Lake District. *By* Professor Harkness, *F.R.S., and* Dr. H. A. Nicholson, *F.G.S.*

After describing the range of the Coniston Limestone, a group of strata the position and age of which had been pointed out many years ago by Prof. Sedgwick, the authors referred to a mass of black shales which rests conformably on these limestones, and which have yielded them a series of fossils new to the horizon in which they occur. These fossils consist of eleven species of Graptolites; five of which belong to the genus *Diplograpsus*, five to *Graptolites*, and one to *Rastrites*. These black shales, which are conformable to the Coniston Limestone, are also conformably succeeded by the Coniston Flag group of Prof. Sedgwick, and they are intercalated with the lower portion of this group. Upon the Coniston flags the Coniston grits of Prof. Sedgwick occur, and the latter are also conformable to the former.

The Coniston grits have fossils in them, some of which have not been hitherto found in the Upper Silurian rocks of Great Britain; this circumstance, taken in connexion with the conformability of the whole of the Coniston series, induce the authors to infer that there exists in the Lake country a mass of rocks which probably attain a thickness of nearly 7000 feet above the Bala limestone and below the Upper Llandovery which have no equal representatives elsewhere in the British Isles.

On the Old Sea-cliffs and Submarine Banks of the Frith of Forth. *By* D. Milne Home.

The author explained the line of old sea-cliff along both sides of the Frith of Forth, which had been formed before the last change in the relative levels of sea and land. He mentioned that its height at the lower parts of the estuary was about 13 or 14 feet above the present high-water spring-tides, whilst near Stirling it was about 31 feet, and to the west about 35 or 40 feet. The author also specified two higher and older cliffs at heights of about 60 feet and 130 feet respectively. He referred to the places where skeletons of whales and seals had been found at heights varying from 18 to 23 feet above the present level of high-water mark, and stated that sea-shells were found in two conditions—viz. first, in undisturbed beds now 14 and 15 feet above high-water mark, where they were entire and perfect; and, 2ndly, in beaches, where they were broken. He also referred to the ancient deltas, or heaps of gravel and *débris* at the level of the old cliff, to be seen at different places, as at Menstrie, Alva, and Tillicoultry. He explained the origin of the estuary of the Frith, by the great east and west fractures in the country adjoining to the north and south. He said that in the Fife coal-field, the downcasts were almost all on the south side of the fractures, and amounted altogether to nearly 2000 feet; and in the coal-field of the Lothians, Linlithgow, and Stirlingshire, the downcasts were, on the other hand, to the north, and even to a greater extent, thus producing a trough or hollow, now filled by an arm of the sea. The rocks in this hollow were covered by various drift-deposits, the oldest being boulder-clay, and, over it beds of stratified clay, sand, and gravel. The gravel was generally on the top, which was accounted for by the water of the estuary shallowing, whereby the currents became more powerful, and thus gravel was laid down where only mud or sand could be laid down before.

The author next proceeded to describe a long ridge of gravel running four or five miles through Callendar Park, by Polmont eastward towards Linlithgow. He stated that its height was from 30 to 60 feet, and, judging from the materials composing it, he considered it had been formed by sea-currents. He said that these gravel ridges were very numerous in our open valleys, and that their direction or course was invariably parallel with the axis or sides of the valley. Though he had not seen the ridge of gravel at St. Fort, described in Dr. Chambers's paper, he could not help thinking it was to be accounted for in the same way, viz. by marine cur-

rents, and not as an effect of ice action. He exhibited some Admiralty charts, showing the submarine banks and spits existing in the English Channel, all of which were in like manner parallel to the sea-coast. If this bank was formed in that way, the sea must have stood at least 350 feet higher than now; and, in that view, an explanation was afforded of several phenomena in the district, such as the smoothed appearance of the hard whinstone rocks of Stirling, Craigforth, Airthrey, Castleton, and Logie. He thought it, however, not at all improbable that ice then floated on the sea; otherwise he could not account for the position of some enormous boulders which he described situated to the east of Stirling, and which evidently had been in some way carried to their present positions. He next adverted to the fact of the old beach-line sloping upward to the westward, there being a rise of at least 20 feet. He did not consider this owing to any unequal rising of the land; he thought it might be explained by the laws of tidal action. He knew a different explanation had been given of the old beach-lines of the Altenfiord of Norway; but, whatever may be the case there, this theory of unequal elevation need not be resorted to for the estuary of the Forth. He next adverted to the opinion recently expressed, that the last change of relative levels between sea and land had occurred since the occupation of this country by the Romans. In that opinion he could not concur. Several facts militated against it. If the sea covered the extensive plains to the west of Stirling, up to the old sea-cliff shown on the map, it would have been impossible for the Romans to have had their road, which had been discovered across the moss of Kincardine, or to have had their fort on the banks of the river below Stirling. Moreover, the caves hollowed out by the sea at Wemyss, in Fife, before the last change of the relative levels, must then have been occupied by the sea, and therefore the remarkable sculptures found on their walls, lately described by Sir James Simpson, must have been executed since the Romans left our island, a notion which, he believed, all archæologists would repudiate. In conclusion, he expressed a hope that some one would undertake a survey of the old sea-cliffs connected with the estuary of the Tay, as he had no doubt they would lead also to interesting conclusions, and serve to check the results he had arrived at after examining the estuary of the Forth.

On the Structure of the Pendle Range of Hills, Lancashire, as illustrating the South-easterly Attenuation of the Carboniferous Sedimentary Rocks of the North of England. By EDWARD HULL, *B.A., F.R.S., of the Geological Survey of Scotland. (Communicated with the consent of the Director-General.)*

The author stated that the completion of the Geological Survey of a large portion of South Lancashire had enabled him to arrive at the conclusions stated in this paper.

After describing the general trend of the Pendle range of hills throughout a distance of about thirty miles, from the neighbourhood of Lathom Park on the south-west to that of Colne on the north-east, the author showed that along this range, and especially at Pendle Hill itself, the "sedimentary" strata of the Carboniferous group attains a vertical development surpassing that of the same beds in any part of Great Britain. Several carefully-measured sections in the neighbourhood of Burnley gave the following results:—

1. Middle Coal-measures (only partially represented in this district).		
2. Lower Coal-measures	2,000	feet thick.
3. Millstone-grit series	5,500	„ „
4. Yoredale series	5,025	„ „
Total	12,525	„ „

And if to this be added the beds of the Middle and Upper Coal-measures which occur in South Lancashire, but have been removed by denudation from off the Burnley district, a total thickness of 18,785 feet would be the amount of thickness which the "sedimentary" beds alone of the Carboniferous group originally attained in this part of England.

This estimate excludes the Carboniferous limestone, which, for special reasons,

the author maintains ought not to be classed with the truly "sedimentary" portion of the group.

Comparing the thickness of these beds in the Pendle district with that of the same formations in the direction of the Midland Counties, as ascertained during the progress of the Geological Survey, the following were found to be the relative proportions:—

	North Lancashire.	South Lancashire.	North Staffordshire.	Leicestershire.
Coal-measures....	8,260	7,635	6000	2500
Millstone series ..	5,500	2,500	1000	50
Yoredale rocks ..	5,025	2,000	2000	50
	18,785	12,135	9000	2600

These figures showed, in the author's opinion, a gradual thinning away of the strata towards the centre and east of England, as far as the Carboniferous rocks can be traced in that direction, till lost from view beneath the more recent formations.

The author pointed to the above sections as bearing out his views regarding "the south-easterly attenuation of the Carboniferous sedimentary rocks" of England, as explained at the Manchester Meeting of the Association, and more fully stated in the Journal of the Geological Society of London, vol. xvi.; and also as having an important bearing on the question of the extension of the coal-fields under the Triassic formations of central England.

Observations on the relative Geological Ages of the principal Physical Features of the Carboniferous Distrct of Lancashire. By EDWARD HULL, *B.A., F.R.S., of the Geological Survey of Scotland.*

In this paper the author endeavoured to show that the upheaval of the Lower Carboniferous rocks along the Pendle range corresponded in time, and nearly in direction, with that which upraised the same beds along the northern boundary of the Yorkshire coal-field; and that this upheaval, running in a line about E.N.E., dates as far back as the interval between the Carboniferous and Permian periods.

2. That the occurrence of small areas of Permian beds on the northern base and slopes of the Pendle range, and resting unconformably on the Lower Carboniferous rocks, as at Clitheroe and Bispham, showed that the upheaval of the Carboniferous rocks took place before the Permian period, and that the amount of denudation must have been very great. According to the author's calculation, no less than 19,000 feet of Carboniferous strata have been removed in the Vale of Clitheroe before the commencement of the Permian period. (See thickness of these beds in preceding paper.)

3. That the upheaval of the Millstone and Yoredale beds along the eastern border of Lancashire, and which resulted in dissevering the coal-field of this county from that of Yorkshire, was later than the period of upheaval of the Pendle range, being in all probability at the close of the Permian and commencement of the Triassic epochs. The general direction of this upheaval was north and south.

4. That the disturbances which produced the system of faults ranging N.W., for which the Lancashire coal-fields are so remarkable, were of later date than either of those above-named; and were to be considered in all probability as having occurred at the close of the Jurassic epoch—certainly later than that of the Lias.

These three systems of upheaval were shown to correspond to the sides of a triangle, of which the first and earliest lay about 20° north of east, the second about north and south, and the third and latest about N.N.W.

On some New Cephalaspidean Fishes. By E. RAY LANKESTER.

Mr. Lankester described a new fish, known formerly by fragments as *Plectrodus pustuliferus.* He also briefly noticed a new and large Cephalaspid from the Downton Sandstones discovered by Mr. Lightbody. A diagram of a restored Cephalaspis, showing some new points in the morphology of the genus, was also exhibited.

On the Goldfields of Scotland *.

By W. LAUDER LINDSAY, *M.D., F.R.S.E., F.L.S.*

The author's conclusions are based on—

1. Personal survey of the gold-fields of New Zealand. It was while visiting in 1861 the auriferous districts of the Province of Otago that he was struck with the similarity, as respects physical geography and geology, between that country and many parts of Scotland, and with the probable parallelism as respects the distribution of gold.

2. Personal comparative survey of Scotland, and its principal outlying islands, since his return to Scotland in 1862, in order to determine how far such a parallelism really exists.

3. Inspection of the specimens of gold and gold-rocks in the principal international exhibitions and national museums of Britain and France, Australia, and New Zealand.

4. Comparative study of the literature of gold in Scotland and other auriferous countries.

His special conclusions as regards the Scottish gold-fields are founded mainly on—

1. The similarity of the rocks (Lower Silurian) of a great part of Scotland to those of most other auriferous countries.

2. The abundance in Scotland of the minerals with which gold is most commonly associated in the richest auriferous countries; *e.g.*,

  a. Metallic oxides (iron and copper): magnetic ironsand, containing (or not) oxide of titanium.

  b. Metallic sulphides (iron, copper, lead; and zinc).

3. The actual discovery of gold, both in recent and former times, at various points between the extreme north and south of Scotland.

His propositions concerning the gold-fields of Scotland are, that—

I. Gold is much more extensively or generally diffused over Scotland than has been hitherto supposed.

II. The Scottish gold-fields may be divided geographically or topographically into two great areas, viz. the

  (A.) *Great Northern*, which is naturally subdivided by the Caledonian Canal. The northern half occupies the longitudinal axis of the northern peninsula of Scotland, and comprises the greater part of the counties of Sutherland and Ross, and of Inverness and Argyle north of the Caledonian Canal. The southern half lies between the said canal and the valley of the Tay, and forms a transverse belt across Scotland, comprising a great part of the shires of Inverness and Argyle south of the canal; and of Aberdeen, Banff, Kincardine, Perth, Forfar, Stirling, and Dumbarton-shires.

  (B.) *Southern*—includes great part of Dumfries, Kirkcudbright, Wigton, Ayr, Selkirk, Peebles, and Lanark-shires; and more particularly parts of the districts of Nithsdale, Annandale, Eskdale, Ettrickdale, Tweeddale, and Clydesdale; Carrick; and the Lammermuirs (in Haddington and Berwick)—all south of the Forth.

III. Actual discoveries of gold have been made at different times in the following localities:—

  (A.) Sutherlandshire—Kildonan on Helmsdale Water.

  (B.) Perthshire—1. Breadalbane: area of Loch Tay and head waters of the Tay (Tyndrum and Taymouth).

    2. Upper Strathearn: area of Loch Earn and head waters of the Earn (Glen Lednock: streams falling from the north into Loch Earn; Ardvoirlich, south side of Loch Earn; Glenturrit).

    3. Glenalmond: Glenquoich and other valleys of the Grampians.

  (C.) Forfarshire—Clova district: "Braes of Angus," Edzell, and Glenesk.

  (D.) Aberdeenshire: area of the Dee (Braemar, Invercauld, coast about Aberdeen).

* Details will be found in a paper on the "Gold and Gold Fields of Scotland" in the Transactions of the Geological Society of Edinburgh for 1867-68.

(E.) Argyleshire: Dunoon.
(F.) Lanarkshire: Headwaters of the Clyde, including the rich Crawford Moor or Leadhills district (Elvan water, Glengonner, Glencaple, Mennlock and Wenlock, Short Cleuch, Lamington Burn).
(G.) Peeblesshire: Headwaters of the Tweed (Mannor water, which flows north to the Tweed; Megget water, which flows south to St. Mary's Loch; various feeders of the Yarrow; Glengaber).
(H.) Dumfriesshire: Headwaters of the Annan (Moffatdale: streams falling into Moffat water; Hartfell range above Dobbs Linn).

IV. The richness of the Scottish gold-fields is illustrated by the following facts*:—

(A.) The limited area of the Leadhills yielded at one time (sixteenth century), to systematic working, half a million worth of gold.
(B.) In various public or private museums *nuggets* of Scotch gold are exhibited of the following weights:—
(1) 2 lbs. 3 oz. = 27 oz. = 12,960 grs.; worth at current price of gold in Australia (= £4 per oz.) £108: Leadhills: collected about 1502: the largest mass of native gold recorded as having been found within historic times in Scotland.
(2) 2 oz. = 960 grs.: Breadalbane.
(3) 1 oz. 10 dwts. = 720 grs.: Leadhills.
(4) 10 dwts. = 240 grs.: Kildonan.
(5) 30 grs.: Leadhills (1863).
(6) 6 grs.: Moffatdale (1863).
(7) Nuggets of 2 or 3 grs. are frequently found at Leadhills at the present day.

V. Geologically the area of the Scottish gold-fields corresponds to that occupied by the *Lower Silurian* strata and their drifts: in the south represented by the greywackes and graptolitic slates of the Lowthers; in the north by the micaceous schists of the Grampians.

VI. Gold in Scotland is *not*, however, necessarily confined to the Silurian area. In other countries it has been found in rocks of so many different characters and ages, that it is impossible to predicate gold will *not* be found in any given district or rock in Scotland. In particular, gold has been found in *Laurentian* rocks in Canada, Nova Scotia, and Sweden; hence it may at least be looked for in the area of Laurentian gneiss in Scotland, viz. in the Hebrides and western seaboard of Sutherland and Ross-shires. In Canada it occurs also in *Upper Silurian* strata; so that it is possible our Pentlands may prove to be auriferous. In California, Australia, New Zealand, and other auriferous countries, gold occurs in rocks of more recent age, as well as in granites, syenites, sandstones and limestones, and their débris, apparently of very different ages.

VII. The area of diffusion of gold in Scotland, and the extent to which it occurs, can only be determined by systematic investigation, equivalent at least to the "prospecting" of gold-diggers.

VIII. Hitherto, with certain limited and local exceptions, there has been no such systematic gold "prospecting" in Scotland.

IX. "Prospecting" for gold should form part of the duties of the staff of the National Geological Survey of Scotland. From its simplicity it is, moreover, an operation quite within the powers of all classes of the community, who possess, with the necessary interest in the subject, the requisite leisure and local opportunity.

X. There are indications (if they do not always amount to proofs) of the existence in Scotland of auriferous *quartzites*—of gold *in situ*—as well as of auriferous "*drifts*" and "alluvial gold." Gold in its matrix has been apparently found at least in Leadhills, Tweeddale, and Breadalbane.

XI. At the present high rates of wages for skilled labour, and with the present rude appliances for its collection, gold-gathering in Scotland is not apparently remu-

* I am further informed by Dr. Hill Burton, the learned historian of Scotland, that the gold torcs and other ornaments of prehistoric age found in different parts of our country were, there is every reason to believe, the produce of *native gold*.

nerative as a regular and separate industry. It is remunerative only to these classes of the population the value of whose labour does not exceed 3*d.* per day, the wages of lead-mining averaging 15*s.* per week. But the Leadhills miners find it a profitable occupation for their leisure hours, and they obtain a ready market for considerable quantities at prices varying from 5*d.* to 7½*d.* per grain=£12 to £15 per oz. Gold to the extent of 500 to 1000 grs. is occasionally collected in Leadhills in a few days for the local proprietors.

XII. Before it can be properly discussed how far, or whether gold-washing is destined again to become a national industry in Scotland, it must be determined what is the extent and richness of the Scottish gold-fields. Present data are of the most imperfect and unsatisfactory kind for determining this point.

XIII. Many improvements have been made of late years in the process of extracting gold from its matrix and drifts; their effect has been to render it remunerative to collect gold which exists in quantities formerly considered too small to be profitable to work. Hence, in so far as the processes hitherto adopted in Scotland have been of the most primitive kind, it is possible it may yet be found expedient systematically to work on the most modern plan some, at least, of the gold-deposits of Scotland.

Regarding it as a *type* of the Scottish gold-fields, the author described in detail the gold and gold-rocks of *Leadhills* (to which he made a special visit in the autumn of 1863), pointing out the numerous parallelisms between it and the Tuapeka gold-field of Otago, New Zealand. He instituted certain other comparisons, *e.g.* between the gold-fields of Scotland and those of Hungary (Transylvania), especially as regards the remunerativeness of gold-washing to gipsies and other idle or nomad classes of the population. In conclusion, he indicated the present vigorous operations of gold-mining or washing companies in Wales and Ireland as an encouragement to systematic investigation in Scotland.

Sur l'Ancien Glacier de la Vallée d'Argelès dans les Pyrénées. *Par* CHARLES MARTINS *et* EDOUARD COLLOMB.

Tous les géologues sont d'accord pour admettre que les vallées des Alpes, des Vosges et des Pyrénées ont été occupées pendant l'époque quaternaire par d'immenses glaciers qui descendaient souvent dans les plaines voisines. La carte de l'ancienne extension des glaciers des Alpes et des Vosges a été faite; celle des glaciers pyrénéens ne l'est point encore. Dans ce travail nous commencerons à combler cette lacune en décrivant le plus grand des glaciers du versant français des Pyrénées, celui qui provenant des sommets les plus élevés de la chaine centrale s'est avancé la plus loin dans la plaine.

C'est autour des pics de Neouvielle, Long, de Vignemale, et dans les cirques de Gavarnie et de Troumouse, qu'on retrouve encore les faibles restes du grand glacier qui occupait jadis la vallée d'Argelès et ses affluens; il descendait de la crête des Pyrénées frontière de la France et de l'Espagne et ses racines s'étendaient de l'ouest à l'est depuis le Pic de Cujé-Palas jusqu'à celui de Serre-Mourêne. La vallée principale, celle d'Argelès, aboutissait en se ramifiant aux vastes cirques de Gavarnie, des Oulettes, d'Estaubé et de Troumouse ou d'Héas. Ces cirques déja très-élevés, sont dominés par des sommets dont l'altitude est comprise entre 7500 et 9760 pieds anglais. Le glacier principal avait trois grands affluens: celui de la vallée de Cauterets, celui de la vallée d'Arrens, et celui de Barrèges. Sa longueur totale depuis les Tours de Marboré, jusqu'au village d'Adé dans la plaine de Tarbes, où sont ses dernières moraines terminales, était de 35 milles marins. Cette longueur n'a rien qui doive nous étonner, puisqu'il existe encore dans l'Hymalaya des glaciers plus longs que celui de la vallée d'Argelès.

Pour étudier les traces que cet ancien glacier a laissées après lui, transportons-nous au centre du cirque de Gavarnie. Sur les assises crétacées et tertiaires qui forment les gradins de cet immense amphithéâtre, nous voyons encore les glaciers qui sont les restes de celui que nous allons étudier; mais ils ne dépassent pas les bords des gradins qui les supportent. Dans le cirque même de Gavarnie nous trouvons la dernière moraine terminale de l'ancien glacier composée de blocs calcaires, de grès nummulitiques et de brêches fossilifères, elle sépare la portion la plus reculée du cirque de celle qui la précède du côté du village de Gavarnie. La

vallée qui, succédant au cirque, s'étend de ce village à celui de Gèdre, présente deux longues terrasses parallèles, élevées de 2050 pieds environ au-dessus de la vallée. L'une à droite, appelée la Montagne de Coumely, forme le piédestal des pics de Piméné et de Larrue; c'est une ancienne moraine dont la surface ondulée est couverte de pâturages et parsemée de granges à foin. La terrasse opposée, appelée Montagne de Saugué, est composée de schistes bruns et de quartzites, à formes moutonnées, quelquefois polies et striées par l'action de l'ancien glacier. Sans s'élever sur ces terrasses, le géologue peut se convaincre sur la grande route de Gavarnie à Gèdre que le glacier a poli et usé les escarpemens de la gorge où se trouve l'éboulement appelé le *Chaos*, et avant d'y arriver il remarquera sur la droite de la route un monticule composé de roches moutonnées, polies, striées et portant des blocs erratiques. De semblables roches se remarquent encore sur la droite de la route à la descente sur le village de Gèdre. Près de ce village, M. Emilien Frossard a vu dans les déblais entrepris pour le tracé de la nouvelle route, des blocs erratiques de grès cretacé jaune et friable, avec *Ostrea carinata*, provenant du cirque de Gavarnie. Entre Gèdre et Luz, on remarque en aval du triple pont de la Scia, près du torrent de Lassariou, un rocher schisteux entièrement couvert de blocs granitiques.

Arrivé à Luz, l'ancien glacier de la vallée d'Argelès reçevait le puissant affluent de la vallée de Barrèges. Il était intéressant d'étudier les traces qu'il a laissées dans ce point. Placé sur le Pont de Luz à St. Sauveur, le voyageur peut appercevoir les blocs erratiques blancs qui entourent les granges d'Abié. Ces granges sont construites en granite, et l'un de nous s'est assuré par le baromètre que les derniers blocs étaient à 2770 pieds au-dessus du gave sous le Pont Napoléon. Pénétrons dans l'étroite gorge de Pierrefitte, et nous y verrons des lambeaux morainiques recouverts de gras pâturages plaqués contre le flanc gauche de la montagne. Au sortir de la gorge, sur la droite et au niveau de la route, les schistes sont polis sur leur tranchant, lustrés et creusés par des marmites-de-géant (*pot-holes*) à section circulaire. Là le glacier recevait le plus puissant de ses affluens, celui qui lui apportait les matériaux erratiques les plus nombreux et les plus indestructibles, les granites de la vallée de Cauterets. Le Pic de Viscos, si remarquable par sa forme pyramidale, était le promontoire au pied duquel se réunissaient les deux glaciers, comparable à l'*Abschwung*, qui sépare les glaciers actuels du Lauteraar et du Finsteraar, dont la réunion forme le glacier de l'Aar, si bien étudié par MM. Agassiz, Desor, Vogt, et Dollfus-Ausset. Une immense moraine latérale gauche, parfaitement dessinée sur la feuille 251 de la carte de France, s'étend de l'entrée de la gorge de Cauterets jusqu'à St. Savin. L'un de nous en compagnie de Mr. Arthur Jones, a étudié plus spécialement son extrémité méridionale au-dessus du village d'Arcizans, situé près d'Argelès d'où l'on aperçoit les flancs de la montagne d'Escorne-Crabe déchirés par des ravins creusés dans des terrains meubles. Pour un œil exercé ce sont d'anciennes moraines formant une terrasse dont le niveau moyen est à 2375 pieds au-dessus du Pont de Filhos, près d'Argelès. Du haut de cette terrasse on s'assure que le Pic de Gez qui domine Argelès et s'élève à 3290 pieds au-dessus de la mer, est entièrement couvert de blocs granitiques, preuve que le glacier à acquis sur ce point à une époque de grande extension l'épaisseur considérable de 2045 pieds au moins. La ville d'Argelès est elle-même bâtie sur une moraine granitique fort basse correspondante à l'époque de retrait du glacier: couverte de chataigniers elle s'étend sous la forme d'une longue colline en aval d'Argelès jusqu'au village d'Oost jouant à la fois le rôle de moraine latérale gauche pour le grand glacier d'Argelès, et celui de moraine terminale pour celui affluent par la vallée de Salles.

Nous voici parvenus à l'extrémité inférieure de la Vallée d'Argelès; à droite est le Pic de Jer qui s'élève à 2895 pieds au-dessus de la mer. De la route on apperçoit les blocs qui sont restés suspendus à ses flancs; mais ils ne montent pas jusqu'au sommet; le baromètre nous apprit qu'ils s'arrêtaient à 1300 pieds au-dessus du Gave de Pau. C'est donc l'épaisseur maximum du glacier en ce point, et la moraine dont nous venons de mesurer la hauteur était sa moraine latérale droite. La moraine médiane a recouvert d'un nombre immense des blocs la Montagne de Béout, qui s'élève à 2415 pieds au-dessus de la mer, mais seulement à 1286 pieds au-dessus de la rivière. Sur cette Montagne de Béout, le géologue pourra observer les blocs erratiques dans toutes les positions et avec tous les accidens qui ont été depuis long-

temps signalés en Suisse; les uns se sont brisés en deux dans leur chute; les autres sont suspendus sur des pentes très-fortes, un grand nombre reposent sur des blocs plus petits, et quelques-uns sont perchés sur des piédestaux de trois pieds de hauteur environ. La montagne calcaire du Béout a été en effet érodée par les eaux atmosphériques, elle présente ces profonds sillons que les Suisses appellent *Karrenfelder*, mais certaines parties protegées par de gros blocs granitiques n'ont point été attaquées, et le bloc se trouve élevé sur un piédestal comme ceux qui sur les glaciers actuels forment la corniche d'une colonne de glace dont ils ont empeché la fusion. La moraine latérale gauche du glacier se trouve dans la vallée de Batsouriguière, au pied d'un cône calcaire dénudé appelé Esch, elle est à 1230 pieds au-dessus du Gave de Pau, et la vallée elle-même est, pour ainsi dire, remplie de blocs de granite.

Sortons maintenant de la vallée d'Argelès, et étudions la moraine terminale telle qu'elle se développe au nord de Lourdes: elle forme un grand arc de cercle, passant par les villages de Peyrusse, Loubajac, Adé, Tuloz et Arcisac-les-Angles. Rendons-nous d'abord avec la foule des pélerins crédules à la grotte miraculeuse, où la jeune Bernadette pretendit avoir vu la Vierge le 14 Février 1854. Le calcaire jurassique exploité le long de la route est arrondi, poli et strié partout où les travaux des ouvriers ont mis à nu la surface de la roche. Ces striés sont dirigées du S.S.E. au N.N.O. L'église elle-même est construite sur une roche moutonnée, et au delà, la route présente la coupe d'une moraine avec cailloux rayés et blocs de granite, de schiste, de calcaire et d'ophite.

Pour étudier la portion occidentale de la moraine terminale du glacier de la vallée d'Argelès, il faut suivre le chemin de fer de Lourdes à Pau. Près de la Gare du *railway* on trouve les grès cretacés du cirque de Gavarnie à l'état erratique, et partout dans les tranchées des granites, des marbres blancs, des schistes, et des gros blocs de calcaires noirs, rayés et empâtés dans la boue glaciaire. Si l'on s'élève sur les collines qui dominent le chemin de fer, on les trouve également couvertes de blocs presque tous granitiques, et dont quelques-uns ont jusqu'à quinze pieds de longueur. De ces collines on découvre le petit lac de Lourdes; il a 1760 yards de long, et est élevé de 1270 pieds au-dessus de la mer. C'est un lac morainique: il est barré à sa partie inférieure qui se termine par une tourbière, et se déverse en amont comme d'autres lacs morainiques, ceux d'Orta, de Varèse, de Côme, au revers meridional des Alpes, de Gérardmer dans le Vosges, de Llyn Llydaw près du sommet du Snowdon dans le pays de Galles. Si l'on se dirige de Peyrusse vers Mourles, propriété de M. Fould, on suit le bord de la moraine, et l'on reconnaît que toutes les collines qui entourent le lac sont couvertes de blocs erratiques, abondans surtout dans les parties couvertes des fougères (*Pteris aquilina*) et dans le bois de chênes ou de châtaigniers. Les plus gros blocs sont entre le lac et le village de Poueyferré; l'un d'eux de granite blanc avec mica noir, à 30 pieds de long sur 22 de large. Sur les bords de la route de Lourdes à Tarbes, on voit également à un mille et demi de Lourdes, un bloc pyramidal de lumachelle, qui marque, pour ainsi dire, la limite de la région des blocs.

La vallée de Lourdes à Adé, que le chemin de fer de Tarbes parcourt dans toute sa longueur, forme, pour ainsi dire, l'axe de la moraine terminale de l'ancien glacier. Entre Lourdes et Adé, sur une longueur de deux milles le chemin de fer coupe sept moraines parfaitement reconnaissables. La dernière après le village d'Adé, a 50 pieds de haut; elle est comme les autres entièrement formée de matériaux meubles —sables, cailloux, blocs mêlés confusément, et porte à sa surface de gros blocs de quartzite et de granite. A la suite de cette moraine, la plaine est nivelée et recouverte d'un sable argileux jaune, semblable au *loess* de la vallée du Rhin. La première colline coupée par le chemin de fer après Adé est composée de schistes métamorphiques traversée par un dyke d'ophite dont les parties exposées à l'air se décomposent en boules. Le loess se prolonge dans la direction de Bordeaux jusqu'à Aire, sur une longueur de 43 miles. Sur la carte géologique de France de MM. Dufrénoy et Élie de Beaumont il est colorié comme les sables des Landes dont il diffère notablement.

La partie orientale de la moraine terminale de l'ancien glacier d'Argelès ne présente rien de remarquable; seulement nous signalerons les nombreux blocs qui recouvrent les collines qui bordent la vallée entre Lourdes et Arcisac-les-Angles, sur la route de Lourdes à Bagnères de Bigorre. D'une manière générale la moraine s'est beaucoup plus étendue vers l'occident que vers l'orient, ce qui devait être par-

ceque les affluens du glacier étaient beaucoup plus nombreux et plus puissans sur la rive gauche que sur la rive droite. Quant à la distribution des matériaux, j'observe que les grès cretacés et les schistes dévoniens avec *Retepora* du cirque de Gavarnie caractérisent la moraine médiane de l'ancien glacier; les granites blancs à cristaux de Tourmaline de la vallée de Cauterets, la moraine latérale gauche; les ophites et les quartzites la moraine latérale droite. Cette distribution se retrouve dans la moraine terminale qui s'étend au nord de Lourdes dans la plaine sous-pyrénéenne.

Nous terminerons ce mémoire en fournissant une preuve zoologique de la période de froid qui a déterminé l'ancienne extension des glaciers pyrénéens. Notre ami M. Lartet, qui connaît si bien le bassin sous-pyrénéen, qu'il a longtemps habité et où il a fait ses plus belles découvertes, nous a donné la liste des animaux de l'époque quaternaire, déterminés par lui dans le sud-ouest de la France. Tous ont été trouvés dans le diluvium et dans les cavernes et même dans les alluvions modernes. Tous coexistaient avec les animaux qui habitent actuellement le pays; mais les uns sont maintenant relégués dans les régions septentrionales de l'Europe ou dans l'extrême nord; les autres ont complétement disparu. Le caractère général de la faune est boréal, et indique un climat plus froid que celui qui existe actuellement; on en jugera par la liste suivante.

Liste des Animaux éteints ou émigrés trouvés dans les terrains quaternaires et les cavernes du sud-ouest de la France. (Ed. Lartet.)

MAMMIFÈRES.

Elephas antiquus, Falc. Alluvions quaternaires de la Réolle (Gironde).

Elephas primigenius, Blum. Alluvions quaternaires de l'Arriège, du Gers, haute Garonne; cavernes du sud-ouest de la France.

Rhinoceros Merckii, Kaup. Alluvions anciennes du plateau de la Roque, Bordeaux; cavernes de la vallée de Campan et de la Dordogne.

Rhinoceros tichorhinus, Cuv. (*R. antiquitatis*, Blum.). Cavernes des Pyrénées; alluvions de la Garonne et de la Charente.

Bos primigenius, Boj. Alluvions quaternaires, et cavernes dans tout le sud-ouest de la France.

Bison Europæus, Cuv. (*B. priscus*, Boj.). Alluvions quaternaires, et cavernes de toute la région.

Ovibos moschatus, de Bl. (*B. moschatus*, Gmel.). Sous des abris de rochers, Gorge d'Enfer et de la Madeleine (Dordogne).

Cervus megaceros, Hart. (*C. hibernicus*, Owen). Brèche de l'Estalient près Bagnères, Sepulture d'Aurignac; alluvions de Clermont (haute Garonne); Station de Laugerie-haute (Dordogne).

Cervus tarandus, L. Cavernes des Pyrénées, Rebenac, Espalangue, près de Lourdes, sépulture d'Aurignac, haute Garonne, &c.

Capra hispanica, Schimp. (Bouquetin). Cavernes diverses des Pyrénées, de la Dordogne, de Tarn et Garonne, vivait alors dans les plaines.

Antilope rupicapra, Erxl. (Isard, Chamois). Cavernes des Pyrénées, de Tarn et Garonne, de la Dordogne, &c.

Antilope Saiga, Pall. Représenté seulement par des cornes dans les cavernes de Tarn et Garonne, et de la Dordogne.

Castor Europæus, Brandt. Cavernes des Pyrénées, de Tarn et Garonne, et de la Dordogne.

Arctomys marmotta, L. Brèche de l'Estalient près Bagnères.

Arctomys, sp. n. Grotte de Lacombe-Tajac (Dordogne).

Spermophilus, voisin du *Sp. erythrogenys*, Brandt, ou *Parryi*, Richards. Grotte des Eyzies (Dordogne).

Ursus spelæus, Rosenmüller. Cavernes des Pyrénées; abondant dans celles de l'Arriège, Tarn et Garonne, Dordogne, &c.

Felis spelæa, Goldf. Cavernes des Pyrénées centrales, sépultures d'Aurignac; alluvions anciennes de Clermont (Arriège); cavernes de la Dordogne, &c.

Felis Lynx, L. Caverne de Massa (Arriège), des Eyzies (Dordogne).

Felis, voisin du Léopard. Cavernes des Pyrénées; grotte supérieure de Massat et de Bourchette (Arriège).

Hyæna spelæa, Goldf. Alluvions quaternaires du plateau de la Roque, près Bordeaux; cavernes des Pyrénées, de la Dordogne, &c.

Hyæna striata, Zimm. (*H. prisca*, Marcel de Serres). Brèche de l'Estalient, près Bagnères.

OISEAUX DES CAVERNES. (Alph. Milne-Edwards.)

Gypaetes barbatus, Temm. Cavernes de la Dordogne.
Milvus regalis, Vieill. Cavernes de la haute Garonne.
Falco tinnunculus, Vieill. Cavernes de la Dordogne.
Buteo cinereus, Gmel. Caverne d'Aurignac.
Nyctæa nivea, Vieill. (*Strix lapponica*, Gm.). Dordogne.
Hirundo rupestris, Temm. Caverne de Lourdes.
Corvus corax, Vieill. Dordogne.
Corvus pica, Temm. Dordogne.
Pyrrochorax alpinus, Vieill. Dordogne.
Tetrao lagopus, L. Cavernes de Lourdes.
Tetrao albus, L. Dordogne.
Tetrao urogallus, L. Dordogne.
Grus primigenia, Alph. Milne-Edwards. Dordogne.

Parmi ces animaux les Eléphans, les Rhinocéros, le Cerf d'Irlande, les Spermophiles, l'Ours des cavernes, les *Felis*, l'Hyène, et la Grue ont disparu; d'autres ont émigré, soit vers le nord soit sur les hautes cimes des Alpes et des Pyrénées. Ce sont le Renne, le Bœuf-musqué, l'Aurochs, le Bouquetin d'Espagne, le Chamois, la Marmotte des Alpes, le Castor, le Lynx, la Chouette de Laponie et les *Tetrao*. Le caractère général éminemment arctique de cette faune nous montre que le climat des Pyrénées était à cette époque plus rigoureux qu'il ne l'est actuellement. La zoologie confirme donc complétement les données de la géologie.

On the Cambrian Rocks of Llanberis with reference to a Break in the Conformable Succession of the Lower Beds. By GEORGE MAW, *F.G.S., F.L.S., &c.*

A section was exhibited of the lower part of the Cambrian series along the southern bank of Llyn Padarn, which was not visible at the time the Llanberis district was mapped by the Geological Survey.

A cutting on the branch railway from Carnarvon, now in course of formation, has exposed the structure of the lower beds and the most complicated part of the series. Underneath the beds worked for slates in the Dinorwic and Glyn quarries there occurs a considerable thickness of a compact rock obscurely banded with dark olive-green and dull buff, which rests unconformably on the upturned edges of a still more ancient slate-rock. Many of the similar dark-green bands interstratified with the workable slates of the higher series, and which have been grouped with the Cambrian grits and pebble-beds, contain isolated fragments of altered slate, and wherever they are in contact with the blue or purple slates a thin course of altered green slate occurs at the junction.

Towards the lower part of the Upper series in the Glyn quarries the green matter occurs as a multitude of thin bands, in contact with which the slate has been altered to a pale green.

The dark-green bands were found on analysis to exhibit a totally different composition to that of the slate-matrix, and appeared to have been derived from a different source.

With reference to the condition of fusion under which the dykes of greenstone were intruded, judging from the kind of alteration produced in the adjacent slate, the heat could not have been sufficient to effect a purely vitreous liquefaction, as experiments proved that the slaty matrix was fusible at a lower heat than that at which the greenstone was refractory.

On Tertiary and Posttertiary Action in the Pyrenees. By P. W. STUART MENTEATH.

On the Nature and Systematic Position of the Graptolitidæ. *By* Henry Alleyne Nicholson, *D.Sc., M.B., F.G.S., &c.*

The author of this paper, after stating the views of those who had referred the Graptolitidæ to the Cephalopoda, the Actinozoa, the Polyzoa, and the Foraminifera, stated the reasons which induced him to class them with the Hydrozoa, a view originally put forth by Prof. M'Coy. This opinion was shown to be supported by the morphology of the Graptolitidæ, and especially by the existence of a "common canal" corresponding to the "cœnosarc" of the Hydrozoa, from which arose the separate cellules or polypites. As a special morphological point, it was also indicated that the "central disk" of some *Tetragrapsi* and *Dichograpsi* would find a feasible homologue in the "float" or "pneumatophore" of the Physophoridæ, an order of the oceanic Hydrozoa.

Passing from the nutritive to the generative system, the author drew attention to the bodies originally described by himself as the "ovarian vesicles" of Graptolites, and also to those previously described by Hall, pointing out their close affinity with the "gonophores" of the recent Hydrozoa.

The reference of the Graptolitidæ to the Hydrozoa was further shown to be supported by their mode of existence and by the determination of allied forms. As regards the former point, proofs were adduced that the great majority, if not the whole, of the Graptolitidæ were free and unattached, an almost fatal objection to the belief that they were referable to the Bryozoa. As to the second point, attention was drawn to the existence of a form (originally described by the author under the name of *Corynoides calicularis*) which was closely allied to the Graptolites, but which probably represented the Corynidæ or Tubularidæ in the Silurian seas.

The author, in conclusion, declared his belief that the Graptolitidæ could not be referred to any existing order, or even subclass, of the Hydrozoa, standing therefore in the same relation to the latter that the Trilobites do to existing Crustacea. In the present state of our knowledge it seemed, therefore, most advisable to consider the Graptolites as constituting a new subclass intermediate in position between the oceanic and the fixed Hydrozoa; and there were some reasons for the belief that they perhaps represented the original stock, from which the above existing sections of our living Hydrozoa have primarily diverged.

On the Graptolites of the Skiddaw Slates. *By* Henry Alleyne Nicholson, *D.Sc., M.B., F.G.S., &c.*

The author of this communication gave a brief description of the Graptolites of the Skiddaw Slates, a group of rocks forming the base of the great Silurian series of Cumberland and Westmorland. These Graptolites had been described in 1863 by Mr. Salter, who gave a list of thirteen species. Rejecting some of these, the author was now enabled, by the researches of Prof. Harkness and himself, to describe twenty-three species, of which number thirteen are well known in the Quebec group of Canada, three are new, and the remainder occur elsewhere, either in the Lower or Upper Llandeilo rocks. The author pointed out various peculiarities in the forms and distribution of the Skiddaw Graptolites, and showed that by their aid we were able clearly to correlate the Skiddaw Slates with the Quebec group in Canada.

The Graptolites of the Skiddaw Slates were shown to be referable to six genera certainly, perhaps to eight. The genus *Dichograpsus*, Salter, was represented by four species, viz. *D. Logani*, Hall, *D. octobrachiatus*, Hall, *D. multiplex*, Nich., and *D. reticulatus*, Nich. Of the genus *Tetragrapsus*, Salter, four species had also been identified, viz. *T. bryonoides*, Hall, *T. quadribrachiatus*, Hall, *T. Headi*, Hall, and *T. crucifer*, Hall.

The genus *Dendrograpsus*, Hall, was doubtfully represented by branching fragments apparently referable to *D. Hallianus*, Prout, from which *D. furcatula* of Salter appears undistinguishable.

The genus *Pleurograpsus*, Nicholson, was also doubtfully represented by a single new species, provisionally named *P. vagans*.

Of the genus *Diplograpsus*, M'Coy, four species are known from the slates, viz.

D. pristiniformis, Hall, *D. mucronatus*, Hall, *D. antennarius*, Hall, and *D. teretiusculus*, His.

Of the genus *Didymograpsus*, M'Coy, seven species are found, viz. *D. nitidus*, Hall, *D. patulus*, Hall (=*D. hirundo*, Salter), *D. serratulus*, Hall, *D. bifidus*, Hall, *D. sextans*, Hall, *D. geminus*, His., and *D. V.-fractus*, Salter.

Of the peculiar genus *Phyllograpsus*, Hall, two species had been recognized, viz. *P. angustifolius*, Hall, and *P. typus*, Hall.

Of the genus *Graptolites*, Linn., four species had been stated to occur by Mr. Salter, viz. *G. sagittarius*, Linn., *G. tenuis*, Portl., *G. Nilssoni*, Barr., and *G. latus*, M'Coy; but these determinations had been in all probability founded upon fragments of the compound forms.

On the Geology of India. By Dr. Oldham.

On Fossil Fishes of the Old Red Sandstone of Caithness and Sutherland, with notices of some new to those Counties. By C. W. Peach.

The author first mentioned *Pterichthys* as being abundant in Orkney, but until 1863 not a vestige of it had been found in Caithness or Sutherland, when in June of that year he was fortunate enough to turn up, in the thin flaggy beds intercalated amongst the coarse sandstones near John O'Groat's, an exceedingly small species, with small spined arms, delicately but beautifully sculptured. One specimen had two horn-like appendages, which turn right and left at right angles, and, like the others, differs from those found in Orkney, and, if a new species, the author intends to name it after his late valued friend Robert Dick, so that at least one thing belonging to the Old Red Sandstone, for which he did so much, might bear his worthy name. After a full description of the above, he mentioned *Coccosteus*, describing *C. pusillus* of M'Coy, of which he had got nearly a perfect specimen at Murkle, near Castlehill. In one he pointed out that the tail was covered either with scales or a tuberculated skin, a fact not before observed. *Coccosteus trigonaspis* of M'Coy he considered not a good species, it being made from the lozenge-shaped ventral plate of the above species. M'Coy himself was doubtful about it.

From Wick Head he had obtained *Osteolepis brevis* of M'Coy. *Dipterus* he found was a true bony fish, as might be seen by the specimens produced, showing vertebral column, ribs, processes, and interspinous bones. Of *Acanthodes* he had obtained a third species, the *Acanthodes pusillus* of Agassiz.

Holoptychius Sedgwickii he felt sure was also a true bony fish, as seen by the specimen he exhibited, showing similar internal bones to those noticed as occurring in *Dipterus*. All the above fishes were found in Caithness, and as well, probably, a new *Cheiracanthus* and spines of *Diplacanthus longispinus*. At Dornoch, in Sutherlandshire, he had found scales of *Holoptychius* in the sandstones near the sea.

Tristichopterus alatus was next alluded to. This really handsome fish was described by Sir Philip Egerton in Decade X. of the Geological Survey, from imperfect specimens exhibited by the author at the British Association at Aberdeen, in 1859; and although described as a true bony fish, its true place could not be positively made out, from the absence of paired fins, bones of the head, teeth, &c. Specimens of all these were produced, and fully bore out the conclusion which Sir Philip Egerton had arrived at when describing the one got in 1859. After mentioning the probability of his having found (as well as the above) Annelides in Caithness rocks, he stated that he fully agreed with Sir R. I. Murchison, in his triple arrangement of the Old Red Sandstone in the counties of Caithness and Sutherland.

On the Geology and Fossils of the Lingula Flags at Upper Mawddach, North Wales. By John Plant.

Mr. R. Slimon's collection of Crustacea was exhibited.

On the Internal Heat of the Earth. *By* Dr. Julius Schvarcz.*

On the Relation of the Upper and Lower Crags in Norfolk. *By* J. E. Taylor, *Hon. Sec. Norwich Geol. Soc.**

On a new Phosphatic Deposit near Upware, in Cambridgeshire. *By* J. F. Walker, *B.A., F.G.S. &c.*

At the Meeting of this Association at Nottingham, the author communicated a paper on a phosphatic deposit in Bedfordshire; further light has been thrown upon the nature of that bed by the discovery of another deposit near Upware. The most remarkable difference between these deposits is, that the shells, which the author regarded as proper to the beds, exist at Sandy and Potton in a ferruginous condition, but in a calcareous condition near Upware. The reason why the same fossils occur in different conditions in these beds is probably due to the proximity of a coral-reef to the Upware bed; for the coral rag occurs at Upware, and a large supply of calcareous matter would be derived from this source. At Sandy the casts of the shells are impressions in the ferruginous sand, which forms the matrix in which the fossils and nodules are imbedded, whilst at Upware casts of these shells occur composed of carbonate of calcium. The author referred to the water-worn condition of the phosphatic casts at Potton in his former paper, but the ferruginous nature of that bed was unfavourable for the preservation of the shells proper to the deposit; in the Upware bed, however, the calcareous nature of the deposit is highly favourable for the preservation of the shells proper to the deposit; and therefore the difference between the phosphatic casts and the shells proper to their respective beds is more marked at Upware than at Potton. *Bryozoa, Serpulæ,* &c. occur on several of the phosphatic nodules at Upware, having evidently grown on them, the animal having followed the outline of the nodule, which circumstance would tend to show that the nodules have been deposited in a hardened condition in the place where they are found.

Remains of the same fishes that are found in the Bedfordshire deposit occur in this bed; also of the reptiles, including *Dakosaurus* and *Iguanodon.*

The author gave sections of the Upware deposits in the 'Geological Magazine' for July 1867, also a list of the fossils; among these there are a great many species of Brachiopoda, including three new species—*W. Woodwardii, W. Davidsonii,* and *T. Dallasii* (since described in Geol. Mag. October 1867).

The known species of Brachiopoda found in this deposit are of the Lower-Greensand age, including *T. Sella, T. prælonga, T. depressa, T. Fittoni, W. Moutoniana,* &c., *R. Gibbsiana, R. antidichotoma,* &c. This bed likewise contains numerous fine specimens of sponges, Bryozoa, &c., resembling those found at Farringdon; and during a recent visit to the latter locality the author obtained several shells which he has also found at Upware. The author considered these beds at Potton and Upware to be a drift of the age of the Lower Greensand, containing fossils of that age as well as extraneous specimens.

On some Carboniferous Fossil Trees imbedded in Trappean Ash in the Isle of Arran. *By* E. A. Wunsch.

On the Gradual Alteration of the Coast-line in Norfolk. *By* J. Wyatt.

* See Appendix.

BIOLOGY.

Address by the President, Professor William Sharpey, *M.D., Sec. R.S., F.R.S.E.*

I need scarcely remind you that Biology, or the science of the living economy, in its widest sense comprehends whatever relates to the organization, functions, and mode of life of living beings, whether plants or animals, as well as their natural history, that is, their distinctive characters, mutual affinities, systematic classification, and distribution. On account of the extent and variety of the subjects which come under these heads, the Section of Biology in the British Association has been divided on this as on former occasions into departments, which have been determined, not with a view to logical symmetry of arrangement, but for the convenient transaction of business. The department of Anatomy and Physiology, over which I have undertaken more immediately to preside, will include the structure and functions of man and animals; that of Zoology and Botany comprehends the natural history of animals and plants, and will be presided over by Mr. Busk.

Our special science has fully shared in the general advance of human knowledge, which goes onward from year to year with steady progress. The area of ascertained truth is continually widening; the line of contiguity between the known and the unknown is perpetually extending; hence more ample room and multiplied opportunity for passing the frontier and gaining fresh acquisitions in the unexplored region beyond. It has been said that in some fields of science the harvest has been already reaped, and that those who now come after the great discoverers of older times are but the gleaners of what they have left behind. To this opinion I feel sure you will not assent. We, of course, cannot gauge the absolute amount of work remaining to be done in any sphere of mental activity; but, viewed in relation to man's power of research, the unexplored ground in every field of scientific inquiry may be deemed practically inexhaustible. The increasing number of cultivators and the mutual aid which different branches of science lend to each other must naturally quicken the rate of advance. Discoveries in one department speedily find application in other directions, and contribute to onward progress. One step made in advance renders another possible, and the way is thus prepared even for those more conspicuous achievements, in discovery of fact or invention of theory, which at rarer intervals command our admiration. In short, with means of free intercommunication and durable record, the advance of natural knowledge, although not equable and uniform, becomes unbroken and continuous. In adverting for a few moments to the present state of anatomy and physiology, we cannot fail to be impressed by the general prevalence of improved methods of investigation, and the general use of instrumental and other appliances of greater power or greater precision in scrutinizing the intimate structure of the body, and in observing, estimating, and recording physiological phenomena. We see further marks of advance in the increasing application of the other sciences, especially chemistry and physics, to the elucidation of the living economy, and in the readiness with which new discoveries in these sciences are taken advantage of for the prosecution of anatomical and physiological research. Through these means more extended and more precise data are obtained for the discovery or recognition of prevailing laws and the construction of rational theory; and physiology is acquiring more and more the character of an exact study. It is now two centuries since the microscope was first used in anatomical and physiological inquiries, and yet I can remember the time when its use might have been considered exceptional —when, at any rate, it was confined to a very few hands; but now it might almost be said that no physiologist or naturalist is without one. Great improvements are continually being made in the potency, precision, and convenient application of the instrument; and signal advantage has been gained from the use of appropriate reagents for facilitating microscopical investigation. We need not look abroad for examples; some of the most important fruits of recent microscopical inquiry are due to the zeal and sagacity of our own countrymen. I need refer only to the discoveries concerning the intimate structure of the nervous system; and, without invidious selection, I may more especially signalize the well-

known researches of Mr. Lockhart Clarke on the nervous centres, which, I am happy to say, he continues successfully to prosecute,—the discoveries of Professor Beale on the structure of ganglions and of nerve-fibres, and their ultimate distribution in the tissues and organs,—and the interesting observations of Mr. Hulke on the retina. By using high microscopic powers, with the greatest address and skill, Dr. Beale found out exquisitely minute fibrils in the peripheral branches of the nerves, and traced their distribution in various tissues. These inquiries have been followed up by the German histologists, and now it is maintained that nerve-fibres may be traced even into the particles of epithelium. Be this as it may, it is satisfactory to know that, as the functional influence of the nerves has been found to govern in a higher degree and more direct manner than formerly suspected the circulating, secreting, and other nutritive processes, so our knowledge of the anatomical domain of the nervous system is being correspondingly extended. As a marked instance, I may refer to the recent observations on the termination of nerves in the secreting epithelium of glands. In proceeding to say a word on other instrumental applications, I may pass over the continued investigations into the electricity of nerves and muscles, and new determinations, by new methods, of the velocity of nervous excitation, as well as new observations with the ophthalmometer, ophthalmoscope, laryngoscope, and the newly invented cardiograph, and shall content myself with specializing the investigations made in this country into the phenomena of the pulse, in health and disease, by means of the sphygmograph, and the important experimental inquiries of Dr. Sanderson on the influence of the thoracic movements on the circulation of the blood, carried on by means of the hæmadynamometer and additional ingenious apparatus contrived by himself. The account of his observations is contained in the Croonian Lecture for 1866, delivered by him before the Royal Society, which will shortly be published in the Philosophical Transactions. An important contribution to the physiology of respiration was, not long since, derived from a combined chemical and optical investigation, by Professor Stokes, into the oxidation and deoxidation of the colouring-matter of the blood. Spectrum analysis promises much aid in physiological inquiry. It has been already employed by Dr. Bence Jones and Mr. Dupré, in a most remarkable and extensive series of experiments on the time required for the absorption and elimination of foreign matters by the living tissues. The substance used was a salt of lithia, and it was traced into and out of the non-vascular as well as the vascular tissues. The continued employment of chemical means in physiological inquiries scarcely requires any comment. I must nevertheless make an exception in regard to some recent experimental results which lead to an important modification of the views heretofore generally entertained as to the generation of muscular force. From an experiment, now well known, by Fick and Wislicenus, in an ascent of the Faulhorn, these observers concluded that the mechanical force and heat developed in muscular exertion cannot be derived solely or principally from oxidation of the proper muscular tissue. Dr. Frankland has subjected their data and conclusions to a careful chemical criticism, in which he determined experimentally the heat, and consequently the mechanical force, produced by the oxidation of albuminoid substances; and, on comparing this with the results of the Alpine experiment, he has fully confirmed the conclusions drawn from it. It would therefore seem as if a muscle ordinarily uses other materials, probably hydrocarbonous, to be oxidated in the production of force, as a steam-engine uses fuel, and not its own substance. More lately Professor Parkes has made, at the Netley Hospital, two series of very careful experiments, in which the whole of the discharged nitrogen was exactly determined; and his experiments, which are related in two recent Numbers of the 'Proceedings of the Royal Society,' lead to the same general inference as those of the Swiss inquirers; but Dr. Parkes has further found that nitrogen is retained during the actual performance of work, perhaps even taken up in some form by the muscle and assimilated, and that the discharge of it mainly takes place in the period of rest which succeeds exertion. Without unduly protracting these rather desultory remarks, I may be permitted to speak of a new and curious method of research quite recently introduced by a foreign experimenter, which has as yet been especially employed for tracing the more intimate distribution of the ducts in the liver and kidney, but is possibly

applicable to the solution of other anatomical and physiological questions. It consists in injecting into a vein or introducing into the stomach of a living animal a colouring-matter, which may, after a certain lapse of time, be found filling, and so rendering conspicuous, the gland ducts through which it is being eliminated from the system. It is needless to pursue these considerations further, and it is not my purpose to attempt anything in the nature of a general survey of the recent work done in our science. The number of active workers has so greatly multiplied, and the published results of their labours have become so immense in extent and variety, that, to me at least, it would be a hopeless task to present within reasonable compass any consistent and intelligible summary. In one of the lately published annual reports on the progress of anatomy and physiology, I find that the writers referred to as having contributed to these sciences within the year are between five and six hundred, and a good many of them are cited for two or more contributions. One fruitful source of this increased production has been the institution in recent years of physiological laboratories in various continental seats of learning, in which practical instruction is given in histological and physiological studies, and where many able and well-trained young men, ambitious of scientific distinction, are engaged in prosecuting original inquiries. No one, of course, can doubt the gain to science thus immensely accruing; at the same time it must be admitted that the eager publication of immature results and hasty conclusions to which some are tempted, and the corrective, or at least diverging statements of others, equally confident, which speedily follow, present in not a few cases an amount of contradiction and confusion most bewildering to any one who desires to master the existing state of knowledge of the subject. But although this is undoubtedly a drawback, it is trifling in comparison with the advantage of manifold activity and accelerated progress. Anatomical and physiological journals, and other channels for the publication of physiological papers, have of late years been on the increase abroad, and augmented facilities are thus afforded for disseminating new matter; and we admire (I might almost say envy) the number and excellence of the graphic illustrations with which they are furnished. Such advantages are not so freely offered to the anatomists and physiologists of this country. Anatomical and physiological memoirs, for the most part, require elaborately executed figures for their illustration, and the expense of a journal illustrated fully and fitly is found to be a serious obstacle to its maintenance, with the limited circulation which a purely scientific periodical has heretofore obtained in Britain. It has sometimes occurred to me that a publication fund might be established, which, under unimpeachable management and control, might be applied especially to defray part of the expense incurred in illustrating scientific memoirs. Such a purpose, I venture to think, is not unworthy of consideration by those who desire to promote knowledge by pecuniary foundations.

Finally, let me say a word on the influence of the British Association in the promotion of our science. The British Association carries on its work in various ways. One most important line of action is the appointment of committees, or individual members, to draw up reports on the progress and existing state of particular branches of science, or to investigate particular scientific questions by actual observation or experiment, and report thereon; and every year sums of money are voted to meet the expenses of such investigations. These reports are published *in extenso* in the annual volume, and are, for the most part, of great and acknowledged value. Biological science has fairly participated in these advantages, and has further profited through the example set by the British Association, which has led other influential bodies to set on foot investigations by similar means. Doubtless it might be held that the same or like advantages might be obtained through a stationary scientific institution, and without such local gatherings and annual visitations as that which we are now attending; but it has been justly said that the periodic meetings of the British Association in different places serve not only to freshen the interest and stimulate the activity of the habitual cultivators of science, but also to render the study more widely attractive, and enlist fresh energies in the pursuit; and then it must be remembered that the subjects for reports and particular lines of inquiry are for the most part suggested or determined by the discussions that take place at these meetings. It must be

confessed, indeed, that the published proceedings (as distinguished from special reports) of the Section of Physiology make no great show in the series of volumes issued by the Association; but, without undervaluing the reports of these proceedings, I would venture to say that they are not, and cannot well be, a just measure of the useful work done. Much of the good effected by the sectional meetings can never be recorded. I remember being present at an assembly of the German Association of Naturalists at Berlin in 1828, and of hearing Oken, one of the most distinguished members and original founders of that institution, declare that the great purpose of the Association was, not to listen to long and elaborate communications, but rather to bring men of kindred pursuits from different parts into friendly relation with each other, affording them the opportunity of freely exchanging information, exhibiting new and interesting specimens and experiments, offering mutual suggestions, and establishing useful correspondence. All, I feel sure, will admit that this promotion of friendly intercourse among men engaged in the pursuit of science and those interested in its advancement is (and let us hope it will long continue to be) one of the great benefits conferred by the British Association.

On the Preservation of Fishing Streams. By Sir JAMES E. ALEXANDER.

Notes on the Structure of certain Hydroid Medusæ.
By Professor ALLMAN, *M.D.*, *F.R.S.*

I. SLABBERIA.

It is well known that in *Slabberia* there occurs upon each of the four radiating canals a definite oval enlargement, which so closely resembles, in external appearance and in position, the generative pouches of *Obelia*, and of several other Hydroid Medusæ, that a similar function has been hitherto, without hesitation, assigned to it. It has, however, nothing to do with generation; it consists of a mere thickening of the walls of the canal, and in no case could any trace of ova or spermatozoa be detected in it.

It is in the walls of the *manubrium* that the generative elements are developed, and the manubrium becomes enlarged by their presence for a definite extent, exactly as in *Sarsia*. Nothing, however, has been discovered which seems capable of throwing further light on the import of the enlargements of the radiating canals.

It will be thus seen that *Slabberia* belongs to that group of Hydroid Medusæ which produces its generative elements in the walls of the manubrium instead of in special generative buds developed from the radiating canals. In other words, it belongs to the true "gonophore" rather than to that form of Medusa to which the author had elsewhere given the name of "blastocheme."

Forbes, the founder of the genus, misled by the peculiar dilatations of the radiating canals, and not recognizing the presence of generative elements in the manubrium, regarded *Slabberia* as a blastocheme; and this view has since been accepted, although the presence of distinct ocelli and the absence of lithocysts might have raised doubts as to its justice.

It may be noticed that Agassiz describes dilatations of the radiating canals in a North American *Pennaria*, and regards them, though with some hesitation, as generative sacs. There can, however, be little doubt that the medusa of *Pennaria* is a true phanerocodonic gonophore, having its generative elements developed in the walls of its manubrium; and it is by no means improbable that the dilatations of the radiating canals in *Pennaria* may have the same significance as those in *Slabberia.*

II. *On some peculiarities in the Structure of* OBELIA.

The little medusa which forms the subject of the present notice is produced by the very common hydroid *Obelia* (*Laomedea*) *geniculata*, from whose gonangia it may be seen escaping in shoals during the whole of the spring and summer months. The marginal tentacles in the recently liberated medusa are twenty-four in number. Of these four are radial, being situated in the same meridional planes with the radiating canals, and between every two radial are five interradial ten-

tacles; they have all a very distinctly chambered axis, composed of a single series of cells whose contiguous walls form the transverse partitions. Each chamber contains a clear homogeneous fluid, with a nucleus which is usually seated on the centre of the partition wall, and imbedded in a mass of granular protoplasm, which is frequently continued through the axis of the cell in the form of a filament.

The chambered axis of the tentacle becomes slightly thicker towards the proximal end, and is here continued into the substance of the umbrella, through nearly the entire of whose thickness it runs. The terminal cell of the tentacle root thus plunged into the gelatinous mass of the umbrella is much larger than any of the others which form the axis of the tentacle. Like the other cells of the axis, it frequently presents a nucleus on some part of its walls.

The axis of the tentacle is surrounded by an ectodermal tube, composed apparently of membraneless cells, and having great numbers of minute, curved thread-cells immersed in it. Near the root of the tentacle its ectoderm is thickened into a cushion-like swelling, which becomes continuous with the umbrella margin. Between the ectoderm and the chambered core of the tentacle is a well-marked layer of longitudinal muscular fibres.

The tentacle is thus absolutely solid in its entire extent, presenting nowhere any trace of an axile tube. There can be therefore no communication between it and the circular canal, which accordingly simply passes over the subumbrellar side of its root.

The author had been unable to find any trace of a velum which, certainly at the period of liberation, does not present a visible rudiment, though in certain positions of the medusa the optical expression of the thickness of the umbrella produces a deceptive appearance which may be mistaken for a narrow velum.

It will be thus apparent that there are two points in which *Obelia* contrasts most strongly with the great majority of hydroid Medusæ, namely, (1) the structure of the tentacles, and their entire want of connexion with the gastrovascular system, and (2) the non-development of a velum.

The condition of the tentacles in *Obelia* is entirely that of those organs in the very aberrant genus *Cunina*, where they are also inserted into the substance of the umbrella by a root chambered like the rest of the tentacle The tentacles of *Obelia*, too, just like those of *Cunina*, are remarkable for their slight extensibility, their motions consisting chiefly in a spasmodic jerking up and down. The umbrella possesses but slight contractility, and the progression of the medusa would appear to be chiefly effected by the fin-like action of the tentacles. The habitually everted condition of the umbrella, which causes what is its inner surface in other medusæ to become here convex, and its outer surface to become concave, would seem to be connected with the non-development of a velum.

III. *The Structure of the Lithocysts in the Medusa of* Campanularia.

In the medusa of *Campanularia Johnstoni* (a medusa referable to the deep-belled section of Gegenbaur's genus *Eucope*) the marginal bodies or "lithocysts" are situated on a chord-like structure which runs round the margin of the umbrella, and which presents a little oval enlargement at each of the points where it supports a lithocyst. This chord-like portion has been noticed in other medusæ, and has been regarded as a nerve-chord with ganglionic enlargements; but it is plainly nothing more than the ectoderm of the lower surface of the marginal canal. The lithocyst is immersed for a slight depth in the marginal enlargement which supports it, and which sends a very delicate extension of its substance over the whole of its free surface; it consists of a spherical, transparent, and structureless vesicle, the greater part of whose cavity is occupied by a soft pulp. In this pulp, which has necessarily a spherical form corresponding to that of the containing vesicle, there is excavated at the distal pole, or that which is opposite to the basis of attachment of the vesicle, a pit-like cavity, and within this cavity, but not entirely filling it, is the spherical, highly refracting concretion. In the spherical pulp itself no trace of structure could be detected, but its surface is marked by twelve or fifteen delicate striæ, which take a meridional course at exactly equal distances from one another. At the distal pole they all terminate distinctly in the margin of the pit-like excavation, and may be thence traced to within a short distance of

the opposite pole, the striæ generally appearing light-coloured when contrasted with the darker intervening spaces. On the nature of these striæ no further light could be thrown; but the author had little doubt that they are what Hensen has incorrectly interpreted as "auditory hairs" in a medusa which he refers to the genus *Obelia*, but which probably belongs to the present type. It will be seen, too, that the structure of the lithocyst in *Campanularia* differs in many respects from that of the same body in the *Geryonidæ* as described by Hæckel, though the meridional striæ with which the surface of the central pulp is marked in *Campanularia* may suggest a comparison with the two supposed "sense-nerves" which Hæckel has observed running in two opposite meridians on the inner side of the wall of the capsule in *Carmarina* and *Glossocodon*.

Notice of some rare Plants recently collected in Scotland. *By* Professor Balfour, *M.D., M.A., F.R.S.*

In this communication Professor Balfour alluded to the localities for rare plants in Scotland, and referred to the statements made as to the supposed disappearance of plants from the zeal of botanical collectors. He stated that a prize had been offered by the Maharajah of Jeypore to the Botanical Class of the University of Edinburgh for the best collection of Scotch plants, and that the announcement of this had called forth a severe remonstrance from a London correspondent, who warns the University against allowing such a prize to be given on account of the risk of extirpating rare plants. Professor Balfour showed that such fears were groundless, and that the localities of rare plants had suffered, not so much from botanists as from nurserymen and others who collected for the purpose of sale, as well as from the improved cultivation of the country, drainage, and other agricultural improvements. One rare plant, *Phyllodoce cærulea*, had been nearly destroyed by the rapacity of a Scotch nurseryman; but Professor Balfour was happy to say the plant still existed on the Sow of Athole, and he showed a specimen which had been collected in August last. Drainage was affecting seriously the localities in which *Corallorrhiza innata* was known to grow, but several new stations had been found in Scotland. *Pinguicula alpina* was becoming very scarce, owing to the drainage of the Black Isle. The greatest injury had been caused in the case of ferns, which were now cultivated for sale to a very large extent; and Professor Balfour knew of instances where English collectors had robbed stations for *Woodsia hyperborea* and *ilvensis*, *Cystopteris montana*, *Asplenium septentrionale*, *A. germanicum*, and others. In these cases money-making was the object. He was glad to say, however, that new localities were constantly being discovered, and that botanists were now becoming cautious in their communication to ruthless vendors of plants. New localities had been found for *Goodyera repens* near Edinburgh and near Melrose. *Corallorrhiza innata* had been found in several places in Fife and Perthshire.

Professor Balfour then noticed an addition to the flora of Scotland in the case of *Apera interrupta*, which occurred in large quantity on Dirleton Common, about twenty miles east from Edinburgh. He then gave an account of a trip to Dalwhinnie in August last, during which he and his party had visited the Sow of Athole, the Boar of Badenoch, Loch Ericht and Loch Laggan, Ben Aulder, and Corryarder. He described the occurrence of snow in large quantity on the hills, and mentioned that he observed *Polypodium alpestre* and *P. flexile* in abundance. He had gathered in Glen Tilt *Dicranum Grevillianum* and several other rare mosses which had been recently discovered by Miss McInroy of Lude. He had visited the station of *Polypodium calcareum*, near Aberfeldy, and observed the fern growing plentifully in an old limestone-quarry. He noticed also the occurrence of *Aster salignus* in considerable quantity in several stations on the banks of the Tay, particularly near Dalguise and Seggieden. In the latter place it had been seen for many years by Colonel Drummond-Hay.

On the Claims of Arboriculture as a Science. *By* William Brown.

The author said that those points in the scientific culture of trees the elucidation of which is so much wanted to guide and assist the practical forester, or those

influences, good or bad, which trees are found to possess over the soil and climate, had not been taken up by the Association. He wished now to claim for arboriculture such a position in science as its importance deserved. He showed that trees occupied in Britain one twenty-second part of the whole area, or only one-third less than what is under green crops. To every eleven acres of cultivated land there is one of wood, and one to every sixteen of uncultivated. The gross yearly value of this wood-crop was stated to be no less than £2,500,000. The effects of trees on the climate were then explained, injudicious clearings or overplanting respectively causing aridity and humidity. The want of a due proportion of a country under a tree-crop is certain to cause irregularity of temperature, violent storms, and dryness; while it may be, on the other hand, over-clothed, so as to bring about just the opposite effects. As illustrative of the effects of trees on the health of the population, reference was made to the districts of Grantown and Abernethy, in Strathspay, which until of late were covered with close masses of plantation and natural forests; but a regular system of thinnings and clearings having been carried out, the result has been a great and gradual decrease of deaths, in consequence, as he fully substantiated by statistics, mainly to the wood-surface having been brought down to a more healthy proportion.

On British Fossil Cycadeæ. *By* W. CARRUTHERS, *F.L.S., F.G.S.*

After describing the structure and peculiarities of living Cycads, the author gave a history of our knowledge of the known British fossil species. Two genera had been described, *Clathraria* and *Cycadoidea*. *Clathraria* had a simple or bifurcated stem, with the internal structure of *Cycas*. The scars on the stem are alternately large and small as in the recent genus, and some fruits found in the same beds with them agree generally with those of *Cycas*. Four species have been found, *Clathraria Lyellii* (Mant.), *C. Mantelli* (Carr.), *C. Bucklandii* (Carr.), and *C. Milleri* (Carr.) A new genus, *Yatesia*, was established for a fossil with a simple stem with uniform scars and having fruits in terminal cones. A single species was known of this genus in Britain, *Y. Morisii* (Carr.). Buckland's genus *Cycadoidea* had bulbiform trunks with small branches permanently attached to the stem. Three species have been described, *C. megalophylla* (Buckl.), *C. microphylla* (Buckl.), and *C. pygmæa* (Lindl. and Hutt.). A fourth genus, named *Bennettites*, in acknowledgment of the great assistance given to the author by J. J. Bennett, Esq., of the British Museum, was established for three remarkable forms, distinguished from all other Cycads in having an oval stem and a single woody cylinder from which the vascular tissue for each leaf separated in a single bundle. The fruit of the genus was described. This consisted of seeds borne on the ends of branched pedicels, which were developed from the apex of short branches in the axils of the leaves. Three species were described, *Bennettites Saxbyi* (Carr.), *B. Gibsoni* (Carr.), and *B. Peachii* (Carr.).

Remarks on the Entozoa of the Common Fowl and of Game Birds, in their supposed relation to the Grouse Disease. *By* Dr. COBBOLD, *F.R.S., F.L.S.*

The author presented a list of upwards of twenty distinct forms of Entozoa which had been recorded as infesting this group of birds. Taking each bird separately, one entozoon only had been described as infesting the red-legged partridge; five had been found in the grey partridge, four in the quail, four in the common grouse, three in the black grouse, four in the pheasant, and, lastly, fourteen in the fowl. It would seem that the prevalence or absence of Entozoa in the grouse had no connexion with the so-called "grouse-disease;" that was an inflammatory disorder of the blood terminating in gangrene and pyæmia. The tapeworm of the grouse had been regarded as a distinct species; but the author had no doubt that it was identical with the *Tænia linea*, which also infested the partridge and quail.

Observations on the Habits of Flyingfish (Exocœtus). *By* Dr. COLLINGWOOD, *M.A., F.L.S.*

These observations were made with a view of discovering the object of the flyingfish's aërial excursions, and also the mode by which they sustained them-

selves so long out of the water, and propelled themselves through the air. The results satisfactorily show that the flyingfish never leaves the water except pressed by its aquatic enemies; and with regard to the second point, although their passage from the water to the air is always accompanied by a rapid vibration of the pectoral fins, such a vibration does not continue, nor does it recur unless the fish passes through a wave-crest, or in some manner wets its fins afresh. In this case a new vibration occurs, and it seems the stimulus of the sea-water produces the vibration in question. But the fish may progress with great rapidity for 70 or 80 yards, *without* any fresh vibration, although it never rises more than a foot or eighteen inches above the surface of the waves.

On Pelagic floating animals observed at Sea. By Dr. Collingwood, *M.A., F.L.S.*

In this paper the author gave an account of observations upon the occurrence and range of certain oceanic Mollusca, Pteropods, compound Tunicata, minute Crustacea, &c., which he had met with in a voyage of considerable duration, chiefly within the tropics. It was illustrated by specimens and coloured drawings.

Notes on Oceanic Hydrozoa. By Dr. Collingwood, *M.A., F.L.S.*

The various species of Lucernariadæ and Physophoridæ formed the subject of this communication. The author referred to the circumstances under which they occasionally occurred in great profusion upon the surface of the ocean, usually all of the same species, at the same time. The shoals embraced, on different occasions, *Aurelia, Rhizostoma, Pelagia, Stephanomia, Physalia, Velella,* and *Porpita.* He especially described the magnificent species of *Physalia*, seen in some abundance near the Equator in the Atlantic Ocean, which were each accompanied by a number of small fishes, which harboured under the shelter of the long tentacles and polypites of the *Physaliæ.*

On some remarkable Marine Animals observed in the China Seas. By Dr. Collingwood, *M.A., F.L.S.*

The author stated that he had found many new species of Nudibranchiata, Planarian Annelids, Crustacea, Echinoderms, &c. upon the shores of China, Formosa, Borneo, and Singapore Straits, of which he exhibited specimens. He described the habits of some remarkable crustaceans which inhabit the sandy shores of these countries, and exhibited some new species of snapping shrimps (*Alpheus*) from China and Singapore. He announced also the discovery of some enormous Actiniæ inhabiting the coral-reefs of the China seas, in which a number of fishes lived semiparasitically. He had met with these Actiniæ on the submerged reefs of the China seas, and also upon the coast of Borneo, and had himself extracted a living fish from one of them. The paper was illustrated by a large series of coloured drawings, made by the author, from life, the greater part of them being of new species, to be afterwards described.

On Trichodesmium, *or Sea-dust. By* Dr. Collingwood, *M.A., F.L.S.*

The curious little Alga remarked by former observers as discolouring the sea in some parts of the world was observed by the author in greatest profusion in the China sea, where it formed a thick scum of many miles in extent. It *never* presented the blood-red appearance of the two species of *Trichodesmium* described by Montague and others, but was always of a uniform pale straw-colour. The author believed that it was a different species from *T. Ehrenbergii* or *T. Hindsii*; and stated that it was confervoid in character, exhibited no spontaneous movements, but was, in some parts of the Indian Ocean, associated with an *Oscillatoria*, which he also described with figures.

Professor Dickson exhibited an abnormal Leaf of *Prunus lauro-cerasus.*

On the Morphology of the Arthropoda. By Anton Dohrn, *Dr. Phil. Jena.*

The author had studied the development of *Palæmon*, *Lithodes*, *Portunus*, and more especially *Mysis* and *Cuma*. He considers the complex respiratory apparatus of *Cuma* as a high degree of elaboration of the simple form met with in *Zoëa*. The micropyle apparatus in the back of *Cuma* and the *Edriophthalma* is nothing but the remains of the dorsal spine of *Zoëa*, or rather of the larval form of the cirripeds, which he calls *Archizoëa*, as he believes *Zoëa* takes its origin from it. The larval membrane of *Cuma* and *Edriophthalma* is nothing but the last remains of the carapace of the Nauplius of the cirripeds. The trefoil-like appendages of *Azellus* are the last remains of the *Zoëa* state, representing the carapace, the spines on the sides of the carapace, and the respiratory apparatus of the *Zoea*. The two pairs of antennæ and the mandibles of the Crustacea are homologous with the three pairs of extremities of Nauplius. The plate and appendage which reach the top of the head in the *Cuma* embryo develope into the carapace and branchial apparatus. The plate in *Cuma* and *Phryganea* are identical. In *Cuma* it becomes the carapace, in *Phryganea* the head-plate; whilst the appendage which in *Cuma* forms the top of the branchial apparatus, forms in *Phryganea* the antennæ.

Amblystegium confervoides, *a Moss new to Britain.* By John Fraser, *M.D.*

While visiting Dovedale, on the 29th of November 1866, for the purpose of examining its mosses, the author was fortunate enough to find a small and in some respects an insignificant moss, but which has never before been observed in the British Isles. It has been submitted both to Mr. Wilson of Warrington and Professor Schimper of Strasburg, who are quite agreed as to what the moss is, and who are satisfied that this is the first time it has been recorded in this country. It has previously been found on the Alps and other parts of Europe.

The romantic dale of the Dove is on the confines of Derbyshire and Staffordshire; it consists of the Mountain Limestone, which rises on either side to a considerable elevation. The new moss was picked up in that portion of it which belongs to Staffordshire, growing in patches more or less extensive, not on the bark of trees, nor on the solid rock, but on detached stones of small size in shady places. It has not been found except in one place, and that over a small area and in small quantity. It is to be hoped that it may be found in other parts of the limestone in that district, as well as in other parts of England.

The moss itself is one of the smallest species. It has much affinity to *Hypnum incurvatum*, differing chiefly in its smaller size, hair-like depressed branches, and in the lax texture of the leaves, which are quite destitute of nerve. At first it was supposed to be *Amblystegium subtile*; but this has a straight erect capsule, no cilia to the inner peristome, and leaves faintly nerved.

The following description of it was drawn up for the most part by Mr. Wilson:—*Amblystegium confervoides* of Bruch and Schimper is monœcious, growing in patches on stones and in shady places; stems creeping, very slender, subpinnate, sparingly branched; branches capilliform; leaves scattered, secund, more or less spreading, ovate-lanceolate, acuminate, entire, nerveless; perichætial leaves longer, erect; capsule cernuous oblong, slightly incurved, pale brown, semipellucid; operculum convex, apiculate; annulus small, deciduous; inner peristome with cilia; outer peristome yellow, fruit-stalk one-third of an inch long.

Specimens and drawings of this moss were exhibited.

On the Destruction of Plantations at Drumlanrig by a species of Vole. By Dr. Grierson.

The ravages of one or more species of *Arvicola* or Vole in the plantations at Drumlanrig in Dumfriesshire have been for years increasing. As far as the author can learn, such was not specially noticed until about the year 1852. Since then the destruction might be represented by high figures. It would seem that the Voles have migratory habits, at times appearing in vast numbers in plantations where they had not been previously noticed, and which they almost completely destroy. The destruction is principally among the young oaks and ash. A ring of bark is gnawed from the tree close to the root, where it is covered with grass. The effect of this ring of

bark being removed is the destruction of the tree. Plantations are liable to be so injured until they are of more than twelve years' growth. Should there be any trees of holly their bark is almost wholly removed. It is in the winter months that the destruction chiefly takes place, especially when the ground is covered with snow. In the examination of hundreds of voles obtained from the Drumlanrig plantations the author distinguished two species: the one corresponds to the *Arvicola pratensis*, the other to the *A. agrestis*. The former bears but a small proportion in number to the latter. There can be little or no doubt that the enormous increase of voles is owing to the relentless extirpation of rapacious birds, and especially of the weasles. While nature gave unlimited fertility to the Rodentia, she bounded their destructive increase by the carnivora; and it is not wise for man, for the sake of sport, to disturb that order. Nature will not suffer him with impunity; the forests will become blighted, and the land overrun with vermin, unless he ceases to destroy indiscriminately the hawks, the owls, and the weasles.

On certain Simulations of Vegetable Growths by Mineral Substances. *By* John Deakin Heaton, *M.D.*

Several observers have noticed the curious arborizations which are developed upon crystals of various salts when immersed in a solution of silicate of soda, varying in form and other characters. Sulphate of iron seems to be the salt whose crystals, when so immersed, produce the most free and beautiful forms; and the observations noticed had been made with this salt. If small fragments of these crystals be dropped into a solution of silicate of soda, formed by diluting the commercial solution with about twice its measure of water, and having a density of about 1·065, very beautiful arborizations will soon begin to shoot perpendicularly *upwards*, attaining the height of 3 or 4 inches in a few hours, consisting of trunks subdividing and ramifying into branches of the greatest delicacy, and exactly resembling a miniature forest of leafless trees, or imitating a mass of confervæ, the mode of ramification and the rapidity of growth varying with the density of the solution used. If a much weaker solution be used, formed by diluting that of the strength previously employed with two or three times its own measure of water, and the crystal be suspended by a thread just below the surface, instead of being allowed to drop to the bottom, roots will shoot *downwards* to the bottom of the glass jar containing the solution, but there will be no growth upwards. By using a solution of an intermediate strength the author had sometimes obtained contorted fibres, like roots, growing downwards, and stems growing perpendicularly upwards on the same crystal, suspended in the middle of the solution. The branches which grow upwards, like the ascending stem of a plant, do not owe their tendency to ascend to their having a lower specific gravity than the liquid in which they are formed; on the contrary, when broken from their support, they at once sink to the bottom of the liquid. The same is true with respect to the downward roots, which sink to the bottom when detached from the crystal on which they form. They are very friable, but have sufficient strength to retain their form for some days if not disturbed; but when lifted out of the liquid, they collapse and fall to pieces. Both silex and the salt of iron enter into their composition, as is evidenced by their colour, which is various tints of olive or bluish green, and their brittle insoluble character. The weaker the solution the more silex and the less iron enters into their composition, the branches being of a paler colour, or almost white, according to the strength of the solution. Examined microscopically, the ultimate ramifications are found to be cylindrical, but gradually tapering to fine needle-like extremities, and tubular throughout; the walls being formed of a delicate incrustation, have no appearance of crystallization, but are finely granular. They subdivide like the branches of a tree; sometimes they are irregularly contorted; sometimes two adjacent parallel branches unite, and again separate just as we see in the threads of microscopic confervæ, the tubular formation, however, being continuous throughout. The tubular character is equally apparent in the roots; but their terminations are more abrupt, sometimes club-shaped.

These phenomena present strong resemblances to the modes and forms of growth of bodies belonging to the vegetable kingdom of organic nature. The

ascending and descending growths of the stem and root of a plant are exactly imitated by these formations, influenced by some force which is neither that of gravitation nor the molecular attraction of crystallization. The growth of these formations is likewise *interstitial*, like that of an organized living tissue; otherwise how can the conical tubular extremities be carried forwards as the branches elongate? or how can these tubular branches unite and again separate, the continuity of the tubes remaining unbroken? These curious formations present another example of the approximation of dead matter to living organizations in the modes in which they increase, and in the forms which they assume; and they seem to increase the difficulty of defining even between the primary division of organized living beings and inorganic substances. If these forms, or an exact photographic transcript of them, were offered to an observer previously uninformed of their true nature and origin, they would in all probability be pronounced to be vegetable. Or supposing such purely mineral substances to have been formed in bygone geological eras, and to have been accidentally fossilized in some primary or other ancient rock, they would very probably, when discovered by recent investigation, be pronounced to be an evidence of organized beings having existed contemporaneously with the formation of such rock.

On the occurrence of Aster salignus (*Willd.*) *in Wicken Fen, Cambridgeshire. By* W. P. Hiern, *M.A.*

The above plant was found on the 25th of August 1867, growing in company with *Cladium Mariscus*, *Thalictrum flavum*, *Peucedanum palustre*, *Carduus pratensis*, *Agrostis canina*, *Lastrea Thelypteris*, and several salices. On the same fen, about two months previously, the author also found the very rare orchid *Sturmia Lœselii* (R.).

The soil of Wicken Fen consists of a thickness of eight feet or more of peat overlying a basin of gault. The peat arises from the decay of various aquatic plants, and carbonate of lime is stored in the ditches by the Charas that grow in them. Attention was drawn to the habit of the specimens which accompanied this paper, for they have the appearance of wild plants. The spot where the Aster grows is in the midst of sedge, and no house is near it. A living specimen has been placed under the care of the curator of the Cambridge Botanical Garden. The following is the name, with references, and the description of the plants:—

Aster salignus (Willdenow), Species Plantarum, tom. iii. pars iii. p. 2040. n. 66; Nees, Gen. et Sp. Asterearum, p. 90. n. 66; Gren. and Godr. Fl. de France, vol. ii. p. 102; DC. Fl. Fr. vol. v. p. 470; Rchb. Flor. Germ. et Helvet. vol. xvi. p. 7; vol. xvii. pl. cmviii. fig. 1; Fl. Dan. vol. xiv. pl. 2475.

Rhizome perennial, creeping. Stem 1–1½ ft. high, solid, herbaceous, leafy, smooth, nearly glabrous, purplish towards the base, erect, simple below, branched above, racemosely panicled; branches five-ranked, corymbose. Leaves sessile, lanceolate, half clasping, not fleshy, bright, scabrous on margins, serrate in the middle, 1-veined; lower leaves attenuate at base, those of the branches linear, entire. Phyllaries loose, linear, nearly equal, outer ones not reflexed. Receptacle slightly convex, alveolate. Florets of the ray ligulate fertile, pale lilac. Florets of the disk yellow tubular. Pappus filiform, dirty white. Fruit compressed, pubescent with longitudinal ribs.

Habitat. Wicken Fen, Cambridgeshire. Flowers in August.

Willdenow's definition of the species is as follows:—

"A. foliis lineari-lanceolatis sessilibus integerrimis margine scabris, inferioribus lanceolatis apice serratis, caule paniculato glabro erecto, calycibus laxis imbricatis.—W.

"Habitat in Germania ad ripas Albis, et in Hungaria. ♃ (v. s.).

"Corolla radiis albis, demum cærulescens."

The species *salignus* of the genus *Aster* belongs to the section *Genuini*, which contains, according to Nees (A.D. 1833), 69 species, and of these none but this species and perhaps another (*A. riparius*, N. ab E.) are natives of Europe; 65 of them belong to the middle regions of North America, and 2 to tropical America.

The present species is a native of Germany, Denmark, and Hungary (?), where it grows in marshy places by the banks of rivers. It may be considered either as

long ago brought from America to Europe in order to furnish a representative of the section to which it belongs, and as afterwards lost from its original habitat, or as the last species of the section remaining in Europe after all its allies had been destroyed. But whatever happened in early ages, the present geographical distribution of *Aster salignus* is not inconsistent with its extending to Britain, where it might be expected to occur in such a locality as Wicken Fen. Professor Balfour exhibited in 1865 specimens of a Scotch Aster, apparently *Aster salignus* (*salicifolius*), before the Botanical Society of Edinburgh.

Note.—A specimen of this plant was found by Mr. Brown of Cambridge, on Wicken Fen in 1864, and given to the Professor of Botany; but it remained unnamed until after the reading of this paper.

On the Boring of Limestones by certain Annelids. *By* E. RAY LANKESTER.

The author drew attention to the boring of *Sabella calcarea* (already noticed by Spence Bate and by De Quatrefages), and also to the more interesting case of *Leucodore*, which was new. *Leucodore* is very abundant on some shores, where boulders and pebbles may be found worm-eaten and riddled by these worms. Only stones composed of carbonate of lime are bored by them. On coasts where such stones are rare they are selected, and all others are left. The worms are quite soft, and armed only with horny bristles. How, then, do they bore? The author maintained that it was by the carbonic acid and other acid excretions of their bodies, *aided* by the mechanical action of their bristles. The selection of a material soluble in these acids is most noticeable, since the softest chalk and the hardest limestone are bored with the same facility. This can only be by chemical action. If, then, we have a case of chemical boring in these worms, is it not probable that many mollusks are similarly assisted in their excavations? The author did not deny the mechanical action in the *Pholas* and other shells, but maintained that in many cases the cooperation of acid excreta was probable. The truth was to be found in a theory which combined the chemical and the mechanical view.

On the Anatomy of the Limpet. *By* E. RAY LANKESTER.

The author drew attention to several points in the anatomy of this interesting mollusk which had escaped previous observers, and which he had ascertained. Prof. Rolleston, of Oxford, had assisted the author in confirming his results and offering suggestions. The points noted were: 1st. The existence of a large yellow salivary gland with four ducts. 2nd. The absence of an oviduct. 3rd. The presence of two capito-pedal orifices, perhaps the exits of the ova and seed. 4th. The structure of the large renal sac, which has two external apertures on either side of the anus, and a minute orifice communicating with the pericardium. The water exuded by the limpet when surprised on its rock probably is squeezed from this organ.

On the Conservation of Forests in our Colonies.
By W. LAUDER LINDSAY, *M.D., F.R.S.E., F.L.S.*

The main object of this paper is to urge the establishment of Boards of Commissioners or Inspectors of Woods and Forests in all the British colonies which are, or admit of being, more or less forest-clad—in order to the

(1) Preservation and improvement of the primitive forests; and
(2) The systematic rearing of new forests by way of substitution or replacement as and before the old ones disappear.

The author enters fully on the grounds which lead to the conclusion that a necessity exists for the establishment of such Boards, and that properly cultivated forests are of primary importance to the progress of all countries, young or old. The author's attention was strongly drawn to the subject while travelling in New Zealand in 1861. The observations he records were principally made in that colony; but subsequent or prior investigation in Australia and various countries or islands of Europe, in connexion with a study of the literature of the subject, lead him to believe that his suggestions will be found to apply *mutatis mutandis* to all our forest-clad colonies in at least the earlier stages of their settlement.

The main propositions of the author as regards New-Zealand forests were the following:—

1. Its present forest area is extremely small in relation to what it evidently was in times comparatively recent. A variety of evidence points to the conclusion that nearly the whole country was at one period luxuriantly forest-clad, the exceptions being the snow-covered barren alps of the interior.

2. The remnants of the primitive forest still existing are rapidly disappearing under the following combinations of destructive agencies:—

I. Natural.
 A. Current geological changes.
  1. Alterations in relative levels of land and water—especially
   a. Local subsidence of former.
   b. Encroachment by sea sand on the coasts.
   c. Erosion of coasts by the sea, and of the margins of lakes and banks of rivers and streams, especially during the storms and floods of winter.
 B. Current meteorological or climatological changes—avalanches, glaciers, wind-storms, lightning, winter torrents and floods (direct agency).
 C. Current zoological agencies—wild animals (*e. g.* birds and insects) eating bark, tearing up saplings, devouring seeds or seedlings, burrowing under the bark or within the timber.

II. Artificial.
 A. Indirect or accidental.
  (1) Cattle and wild pigs.
  (2) Bush fires.
 B. Direct or deliberate.
  (1) Bush-clearing for agricultural purposes.
  (2) Timber-cutting for (*a*) building, (*b*) fencing, (*c*) fuel.
  (3) Track-making for men or cattle.

3. This destruction, which is more or less necessary or inevitable, is materially hastened by the reckless and improvident, or illegal and culpable, timber-felling both by colonists and natives,—more especially as regards the former by
  (1) The abuse of the wood-cutting license; and as regards the latter by
  (2) Deliberate destruction in connexion with their superstitions.

4. With this improvident and unnecessary destruction there coexists a great scarcity of timber, both for fuel and building, in many parts of the colony, rendering expensive *imports* indispensable.

5. No adequate legal check or provision exists for the prevention of abuses and the protection of the forest interests. On the other hand,

6. There exists apparently, on the part both of Colonial Governments and colonists, a blind indifference to, or ignorance of, the importance of
 (1) Preserving to the utmost in a healthy state of growth the old or virgin forests.
 (2) Forestalling their inevitable disappearance, or replacing them, by the systematic cultivation of new forests, whether of
   A. Indigenous, or
   B. Exotic (acclimatized) trees.
 (3) Forest cultivation in relation to climate.

7. Many important problems await solution, affecting both
 (1) The economic value and applications of the existing indigenous timbers, and
 (2) The rearing of new forests,
  which scientific experts, or systematic experiment, are alone probably capable of solving, *e. g.*:—
 (1) A. The best season for felling native timbers in different localities.
   B. The comparative durability in salt and fresh waters.
   C. Their power of resistance to marine boring animals.
 (2) The determination of the species, indigenous or exotic, most suitable for the various purposes of building-timber, shelter, fuel, &c., as respects
   A. Rapidity of growth.
   B. Facility of acclimatization.
   C. Ultimate or permanent economical qualities.

8. When the virgin forest is destroyed by natural or artificial agencies, the valuable timber-yielding trees are not replaced by a young and vigorous growth of the same species, but generally by a different and inferior growth, sometimes wholly fruticose, occasionally only cryptogamic.

9. Future and permanent timber-supplies must be looked for from forests yet to be artificially reared and systematically cultivated, consisting in great measure of introduced or acclimatized (exotic) trees of a hardier growth than those which are indigenous.

10. There is an evident and pressing want of a Board of Forests in New Zealand, with a complete skilled staff suitable to the requirements of so large and so varied a colony; while a similar want exists in all our colonies which are similarly placed.

The author dwelt chiefly on the abuse of the bush license, on sacrifices to a blind and ignorant utilitarianism that are only too common, on indiscriminate and extravagant destruction of valuable timber arising from a loose colonial morality, or a tolerated evasion of the written law, and on those other errors of commission or omission on the part of governments or settlers which illustrate the necessity for the establishment of some authoritative form of supervision and protection over the forest interests.

He instituted comparisons between the condition of New Zealand forests and the history of forest destruction and cultivation in Scotland, the Hartz Mountains, and India, pointing out the fruits of lavish waste and ignorant indifference, and indicating the present forest regulations of the Hartz district in Germany * as models for imitation in all our colonies. The paper concludes by showing the fertile and important results likely to accrue from acclimatization-experiments in relation to forest-culture in New Zealand, especially from the introduction on the large scale of certain of the hardier, rapidly growing trees of Tasmania and Australia.

Is Lichen-growth detrimental to Forest and Fruit Trees †? *By* W. Lauder Lindsay, *M.D., F.R.S.E., F.L.S.*

The author's object was on the one hand to direct attention to the radical differences of opinion that exist regarding the effect of Lichen-growth on trees, and on the other to endeavour to reconcile those differences, and to indicate the inferences that are legitimately deducible from existing data. The paper, however, was intended to be suggestive rather than descriptive; its aim was rather to call attention to the unsatisfactory paucity and character of the facts on record, and to invite the record of *facts* as contradistinguished from mere *opinions*, than to elaborate his own views or results.

One group of scientific authorities regards Lichens as *true parasites*, and as such detrimental to the healthy growth of trees, and depreciative of their value; while another group describes them as *non-parasitic*, as making use of trees simply as *bases of support*—as innocuous, or even as beneficial, to their hosts. The former opinion is that unanimously held by arboriculturists and nurserymen—by all who are concerned with the cultivation of timber, bark, or fruit-trees; while the latter is that usually entertained by lichenologists.

The principal propositions of the author were the following:—

I. That Lichens must be regarded as *true parasites*, drawing certain at least of the constituents of their thallus from the objects on which they grow.

In his work on 'British Lichens,' published in 1856 (p. 50), the author had shown that the Lichen-thallus contains such bases as silica and alumina, iron and manganese, lime, potash, soda, and magnesia, which could not have been derived *from the atmosphere*, from which lichenologists assert Lichens derive their whole nourishment.

II. That nurserymen discard as *unsaleable* trees or shrubs that are Lichen-covered.

* The author gave some description of these regulations after a tour through the Hartz Forest in 1850: *vide* Proceedings of Botanical Society of Edinburgh for 1853, and Phytologist, vol. iv. p. 988 (1853).

† The subject may be found treated at greater length in 'Hardwicke's Science Gossip,' 1867, p. 241; or the 'Farmer,' Oct. 9, 1867, p. 403.

III. That foresters and tanners regard Lichen-coated oak-bark as of diminished value by virtue of such coating.

IV. That arboriculturists consider Lichen-growth a *disease*, or as a *cause* or *result* of disease.

Evidence is unanimous that Lichen-growth should never occur in forests or nurseries which are the subject of proper care; where the conditions of healthy growth are sedulously provided; where the trees or shrubs are properly thinned; where the soil and manure are suitable. Further, the disease of Lichen-growth, when it appears, can be removed or dissipated at will by placing the tree which it affects in more favourable conditions of development, such as transfer to a richer soil or the supply of proper manure.

On Plant-Acclimatization in Scotland, with special reference to Tussac Grass *.
By W. Lauder Lindsay, *M.D., F.R.S.E., F.L.S.*

In May 1866 the author inspected the condition of the Tussac-grass plantations that had been established in 1845 by James Ritchie, C.E., of Perth, on the estates of Sir James Matheson in the Lews (Outer Hebrides). The main objects of his communication were on the one hand to describe the condition of limited plantations of a most nutritious and valuable exotic grass, which is capable of luxuriant growth on otherwise sterile shores in Scotland, and on the other to illustrate certain points in connexion with plant-acclimatization in Scotland that have not attracted that degree of attention which they deserve, viz.:—

I. The necessity, as regards success, in acclimatization-experiments for *imitating the natural conditions of growth*; and

II. The inevitable failure that must result from ignorance of or inattention to these conditions.

From all the evidence he had collected, the author's conclusion was that the Tussac experiment in the Lews was on the whole a failure, but one due solely to inattention to the proper care and cultivation of the grass. Tussac requires protection and care like other crops, and not more so. Suitable regulations for both protection and care were laid down by Mr. Ritchie; and so long as these were carried out or attended to, the plantations thrived, and they only failed after he left the island, and the conduct of the experiment was consigned to those who had a less intelligent conception of its importance, and an inferior interest in its success. The immediate causes of the destruction of the crops of Tussac, which were flourishing in 1852, appear to have been (1) non-protection by fences, and (2) the want of weeding. Cattle were allowed unlimited access, with the result that the plant was destroyed, partly by being trampled down, partly by the roots being grubbed up and eaten. Weeding was not attended to, and in general terms no care was bestowed on its cultivation.

The author believes there is no ground for doubting that *with the same amount of care as is bestowed on other crops*, such as turnips, Tussac grass may be successfully cultivated on many of the bleak and sterile islands and coasts of Scotland, to which it could not fail to become a boon of no insignificant kind.

To what extent is Lichen-growth a test of Age?
By W. Lauder Lindsay, *M.D., F.R.S.E., F.L.S.*

The opinion is, and has been long prevalent among poets, historians, and archæologists, that trees and buildings are aged in proportion to the copiousness of their Lichen-covering; that Lichen-growth may be regarded as a *test* of the antiquity of the natural objects or artificial structures on which it occurs. Poets constantly speak of trees, rocks, or towers as being "*mossed* with *age*;" while archæologists have gone so far as to consider Lichen-growth *diagnostic* of antiquity. The popular name of Lichens, "Time-stains," shows that such a belief is, however, by no means confined to the classes of writers referred to. Botanical writers have fostered this belief by almost uniformly describing Lichens as of very slow growth, attaining to

* The subject may be found treated at greater length in the 'Journal of Agriculture,' November 1867; or the 'Farmer,' Oct. 30, 1867, p. 553.

great age. The object of the author's paper was to exhibit the result of certain researches on the subject of Lichen-growth in relation to the age of the structures on which it occurs, in order to determine how far the current opinions in question are founded on fact. His immediate object was to determine the *rapidity of Lichen-development under favourable conditions*, or, in other words, How soon might a fresh surface of wood or stone become so Lichen-clad as to assume the "hoary" or "time-stained" appearance that is popularly associated with the idea of great age? In endeavouring to solve this question he assumed, as standards of comparison, the megaliths of Stennis in Orkney and Callernish in Lewis, both of which groups of prehistoric remains, undoubtedly of great though undetermined age, he had visited in May 1866, and of whose Lichen-Flora he had published an account in the Transactions of the Botanical Society of Edinburgh (vol. ix. p. 154). On the other hand, he noted the development of Lichen-growth on a variety of recent structures of known age, including

I. Walls of buildings, gardens, and roads: bridges and other edifices of stone: as well as the mortar or cement used in their construction and in their repair from time to time.

II. Fences of sawn timber around fields and gardens: posts, gates, and other structures of fabricated wood.

III. Young trees and shrubs in nurseries, plantations, forests, gardens, shrubberies, and cemeteries.

The conclusion at which he arrives is that within a quarter of a century, in periods ranging from two to five years and upwards, as copious a clothing of Lichens as that which covers the monoliths of Stennis or Callernish may be produced in favourable conditions of growth, and hence that Lichen-growth furnishes *no criterion* of the *antiquity* of prehistoric or other structures.

Additional corroborative evidence was adduced from the history of those Lichens which were or are still collected in Northern Europe, on account of their economical applications, as food, fodder, or dye-stuffs, e. g. *Lecanora tartarea*, *Cetraria Islandica*, and *Cladonia rangiferina*. Their collectors were familiar with the fact that they may look for replacement of the species they remove in a limited number of years, varying generally within a period of from three to five.

The author draws a distinction between rapidity of *primary* development and slowness of *subsequent* growth, showing that the two phenomena may occur consecutively in the same individual—a circumstance which serves to reconcile on the one hand the facts observed as to the rapidity with which a fresh surface, whether of earth, stone, or wood, may become Lichen-coated; and on the other the current opinion among botanists that Lichen-growth is essentially slow, and its duration practically unlimited.

On Polymorphism in the Fructification of Lichens.*
By W. Lauder Lindsay, *M.D., F.R.S.E., F.L.S.*

Ten years ago, while engaged in researches on the secondary or complementary reproductive organs of Lichens, the author met with a number of instances of polymorphism or plurality thereof—especially of the occurrence in the same species of more than one form of spermogonium or pycnidium; and since that date further instances have frequently occurred to him. The forms of polymorphism specially described or referred to in the present communication are the occurrence in the same species of—

I. More than one form of spermogonium.

II. More than one form of pycnidium.

III. Pycnidia in addition to spermogonia, or spermogonia in addition to pycnidia.

IV. Pycnidia instead of spermogonia.

V. Spermatia and sporidia in the same conceptacle.

VI. Different sizes and forms of spermatia and sterigmata, or of stylospores and basidia.

These multiple forms of reproductive organs or bodies were met with chiefly in

* The subject may be found treated more fully in the 'Quarterly Journal of Microscopical Science,' January 1868.

the lower Lichens, in species, *e. g.*, of the genera *Verrucaria*, *Stigmatidium*, *Strigula*, *Calicium*, *Lecidea*, *Abrothallus*, *Opegrapha*, *Graphis*, *Arthonia*, *Trachylia*, *Lecanora*, though they were also found in a few of the higher Lichens, *e. g.* in species of *Parmelia*, *Roccella*, and *Alectoria*.

The following short catalogue of species, in which the author met with deviations from, modifications of, or additions to, the ordinary reproductive organs or corpuscles, illustrates the general subject of his paper, and may indicate the direction in which future observation is likely to prove useful, either by correcting the errors of previous authors, or by confirming and extending their results:—

I. Genus *Verrucaria*.
- *V. Taylori*, *V. chlorotica*, *V. nitida*, *V. epidermidis*, *V. biformis*: two or more forms of spermogonium or pycnidium.
- *V. gemmata*: spermogonia and pycnidia.
- *V. glabrata*: two forms of spermatia and sterigmata.
- *V. atomaria*: spermatia and sporidia in same perithecium.

II. Genus *Arthonia*.
- *A. cinereo-pruinosa*: two or more forms of spermogonium.
- *A. pruinosa*: pycnidia.
- *A. pruinosa*, var. *spilomatia*: two forms of stylospores and basidia.
- *A. astroidea*: spermogonia and pycnidia.
- *A. astroidea*, var. *Swartziana*: two forms of stylospores and basidia.

III. Genus *Opegrapha*.
- *O. herpetica*, *O. vulgata*: two or more forms of spermogonia.
- *O. atra*, *O. varia*: pycnidia.

IV. Genus *Lecidea*.
- *L. parasema*, *L. dryina*: two forms of spermogonia.
- *L. luteola*, *L. petræa*, *L. anomala*, *L. disciformis*, *L. albo-atra*, *L. Cladoniaria*: spermogonia and pycnidia.
- *L. enteroleuca*: pycnidia in lieu of spermogonia.
- *L. abietina*: pycnidia, and two forms of spermogonia.
- *L. flexuosa*: pycnidia.

V. Genus *Lecanora*.
- *L. subfusca*, *L. atra*, *L. Ehrhartiana*, *L. varia*, especially var. *aitema*: pycnidia, and two or more forms of spermogonia.
- *L. umbrina*: pycnidia.
- *L. cerina*: two or more forms of spermogonia.

Similar reproductive irregularities occur *inter alia* in the genera *Strigula* and *Abrothallus*: *Graphis scripta*, *Stigmatidium crassum*, *Trachylia tigillaris*, *Roccella Montagnei*, *Parmelia sinuosa*, *P. saxatilis* var. *sulcata*, *Alectoria jubata*, *A. lata*, *Scutula Wallrothii*, *Neuropogon melaxanthus* var. *ciliatus*.

The pseudo-genus *Pyrenothea* may be regarded as an excellent illustrative group of the organs in question, especially those sections of the genus represented by the old species:—

I. { *Pyrenothea vermicellifera*. / *P. leucocephala*.
II. *P. corrugata*.
III. { *P. aphanes*. / *P. rudis*. / *P. byssacea*.

The paper also notices certain resemblances in form between stylospores and sporidia, and points out that *pycnidia* are much more prevalent among Lichens than is at present supposed. The author describes at length the anatomical or structural distinctions between spermogonia and pycnidia: and makes certain observations on their presumed respective functions, and in general on the physiology of the secondary reproductive organs and corpuscles of Lichens. It would appear, from the author's researches, that links connecting the Lichens with the Fungi more and more closely are constantly being discovered; and that in particular the same plurality of reproductive organs which characterizes the latter will be found probably to a less extent to characterize the former*.

* *Vide* also the following papers by the author:—

I. In Transactions of Royal Society of Edinburgh, vol. xxii. p. 101, "Spermogonia and Pycnidia of the Higher Lichens;" vol. xxiv. p. 407, "New Zealand Lichens and Fungi."

The Abnormal forms of Ferns. *By* E. J. Lowe, *F.R.S., F.L.S., F.G.S.*

The following facts have come under the author's notice during the series of investigations on this interesting subject.

1st. As regards the various abnormal forms that species will assume. It is a singular fact that most of our British ferns put on appearances closely in imitation of each other, that the varieties of each species have many characters in common, and that a certain law of form of variety seems to extend more or less through both British and exotic species. The more usual forms running through nearly all our British ferns are those having the fronds *crested, crisp, imbricated, confluent, corymbiferous, multifid, acuminate, narrow, plumose, interrupted, depauperate, ramose,* and *dwarf*; and not only this, but we have the multiple of these, or the combining together of two or three characters in one frond, such as the *narrow-crisped*, the *multifid-crisped*, or the *narrow-multifid*, as examples.

Most of these abnormal varieties have been been found wild, and a large proportion in localities where the species is neither abundant nor luxuriant in growth. Of course, springing from an individual plant, it occupies time and care in raising duplicates from spores; and in doing this, singular accidental sports have been raised and a new method of obtaining varieties detected.

2nd. As regards the gathering and sowing the spores of these sports. It seems from these experiments almost an established fact that spores gathered from one portion of an abnormal frond will produce different varieties from those of spores gathered from another portion of the same frond; that if an accidental abnormal frond, or portion of a frond be fertile, it is not impossible to reproduce from its spores plants having fronds in imitation of the accidental abnormal form.

If by cultural means we can induce the growth of singular fronds, we are very likely to perpetuate the variation of form from the spores. By removing the drainage from the roots of plants that had completed their autumnal growth and inducing an unnatural and sickly condition for several months, and only repotting and giving a generous treatment when the fronds were almost ready to unfold, this caused them to produce abnormal fronds in both the British and exotic species.

3rd. Our knowledge of the reproductive organs of ferns is obscure, and it has been said that the fern *Asplenium microdon* is a hybrid between *Asplenium marinum* and *Asplenium lanceolatum*, that *Lastrea remota* is a hybrid between *Lastrea spinulosa* and *Lastrea filix-mas*, and perhaps that *Asplenium germanicum* is a hybrid between *Asplenium septentrionale* and *Asplenium ruta-muraria*. Now it does not appear that these ferns have ever been reproduced from their spores; and therefore (if we may accept these as hybrids) that hybrids of species are unproductive, whereas the varieties raised from a species can readily be reproduced by spores.

On some Points in the Anatomy of the Thysanura.
By Sir J. Lubbock, *Bart., F.R.S., Pres. Ent. Soc. &c.*

The author remarked that the Thysanura, though extremely numerous, and in many cases very pretty little creatures, had attracted but little attention, owing, perhaps, to their great delicacy and the consequent difficulty of preserving them in a satisfactory condition. Under any decaying log of wood, under damp leaves, in long grass, in short, in almost any damp situation, the Thysanura form no small proportion of the population. Like other insects, they have six legs, but they never acquire wings. The tail is generally provided with two long appendages, which are bent forward under the body, and thus form a spring, by means of which the animal is enabled to jump with great activity. A *Sminthurus*, for instance, measuring one-tenth of an inch in diameter, will easily jump up twelve inches in the air. This, however, is due mainly, not to muscular power, but to the elasticity of

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II. In Proceedings of Royal Society of Edinburgh, vol. iv. p. 174, "Spermogonia and Pycnidia of the Higher Lichens."

III. In Transactions of Linnean Society of London, vol. xxv. p. 493, "New Zealand Lichens."

IV. In Journal of Linnean Society of London, vol. ix. p. 268, *Arthonia melaspermella*.

V. In Quarterly Journal of Microscopical Science, January 1857, *Abrothallus*.

the spring. The muscles draw the spring forward and bring it under a small latch or catch; directly this is relaxed, the elasticity of the organ jerks the spring back, and throws the creature upwards and forwards. The author described in detail the muscles by which the spring is moved. Another remarkable peculiarity, and in the author's opinion the special characteristic of the Thysanura, is the presence, on the first abdominal ring, of a process which acts as a sucker in the Poduridæ, and in *Smynthurus* gives rise to two long filaments which serve the same purpose. The author described the arrangements of the muscles by which this curious apparatus is moved. He then described the digestive and respiratory organs; and after pointing out that *Smynthurus* and *Papirius*, though very nearly allied in external character, differ entirely in their method of respiration, the latter genus being almost or entirely deficient in tracheæ, he proposed, therefore, to form for it a new family, which he proposed to call Papiriidæ.

Remarks on Mr. J. G. Jeffreys's Collection of Hebridean Annelids. By Dr. M'Intosh.

The total number of species amounts to fifty; though this is not a large collection, many of the species are very rare. Of the forms for the first time noted in Britain are *Lætmatonice filicornis*, Kinberg (and this he believed to be the same as Dr. Baird's *L. Kinbergi*), *Praxilla prætermissa*, Malmgren, *Rhodine Lovéni*, Mgrn., *Amphicteis Gunneri*, Sars, and *Heteronereis fucicola*, Œrsted.

Those at present considered new are a second species of *Amphicteis*, a peculiar *Lumbrinereis* with eyes, a form allied to *Travisia*, but furnished with forked bristles, a *Trophonia*, and an *Idalia*.

Report on the Invertebrate Marine Fauna and Fishes of St. Andrews. By Dr. M'Intosh.

The richness of the coast-line at St. Andrews in marine animals was pointed out—a state in some measure due to the varied habitat afforded by a smooth sandy beach and a rocky border, with a large surface of tidal rocks. Its proximity to fertile coralline ground and the haunt of many deep-sea rarities, which are tossed on shore by storms or procured from the stomachs of fishes, all combine to render it a most interesting field for the zoologist. Lists of species in the various departments were given, and the most remarkable forms alluded to, such as *Sagitta bipunctata*, *Molgula arenosa*, and *Pelonaia corrugata*. The Mollusca number 170 species.

On the Annelids of St. Andrews. By Dr. M'Intosh.

The list of Turbellaria, Teretularia, and Annelida consists of 104 species, and besides there are 6 Gephyrea.

One of the Turbellaria is new to Britain, viz. *Vortex capitata*, Œrsted: one of the Teretularia is also new, viz. a *Borlasia*, from deep water. He mentioned that he had observed no structural difference between *Cephalothrix rufifrons* and *C. filiformis*, and none between *Ommatoplea alba* and *O. rosea*. The only "*Borlasia*" *purpurea*, Johnst., met with in Britain is an Ommatoplean worm, which differs totally in structure from a true Borlasian.

Amongst the Annelids new to Britain are *Halosydna gelatinosa*, Sars (*Alentia gelatinosa*, Malmgren), and *Nereis virens*, Sars (*Alitta virens*, Malmgren), by far the largest British marine worm yet encountered. *Nereis Sarsii*, Rathke, a distinct species, has been confounded with *N. brevimana*, Johnst., and consequently has not been previously mentioned as British. The *Syllis armillaris* of Dr. Johnston includes two species, one of which abounds under stones between tide-marks, whereas the second comes only from deep water. Other additions to the British fauna are *Castalia punctata*, Œrsted, *Notophyllum polynoides*, Œrsted, *Phyllodoce grœnlandica*, Œrsted, *Eumida sanguinea*, Œrsted, *Eteone pusilla*, Œrsted, *Ammochares Ottonis*, Grube (probably the *Ops digitata* of Dr. Carrington), and a *Leiocephalus*. The *Terebella figulus* of Dalyell is not *T. constrictor*, Montagu, but a distinct species with 24 pairs of bristle bundles, whereas *T. constrictor* has only 17 pairs. *Physelia zostericola*, Œrsted (*Nicolea zostericola*, Malmgren), is common.

The new species comprise a *Lumbrinereis* and a boldy marked brown *Autolytus*. Other interesting though not new species are *Harmothoë Malmgreni*, E. R. Lankester, *Nychia cirrosa*, Pallas, *Sigalion boa* and *Mathildæ*, *Dodecaceria conchurum*, *Sabella viridis*, *Scalibregma inflatum*, and *Mœa mirabilis*.

Dr. M'Intosh exhibited some very beautiful drawings of Worms to be published by the Ray Society.

Sur les Racines Aérifères ou Vessies Natatoires, la synonymie et la distribution géographique de quelques espèces aquatiques du genre Jussiœa. Par Charles Martins, *Professeur et Directeur du Jardin des Plantes de Montpellier**.

On Polliniferous Ovules in a Rose. By Dr. M. T. Masters.

In this paper a general review of the principal malformations to which the ovule is subject was given, together with the details of a case wherein the ovules in a rose (*Rosa arvensis*) presented in some degree the structure and functions of the anther, there being present not only perfect pollen-grains, but fibrous cells such as are usually met with in the anther. A somewhat similar case has been recorded in a passion-flower by Mr. James Salter in the 'Linnean Transactions.'

Notice of Dredging by the late H. P. C. Möller, off Fair Isle, between Orkney and Shetland. By O. A. L. Morch, *of Copenhagen.* (*Communicated by* J. Gwyn Jeffreys, *F.R.S.*)

Hans Peter Christian Möller, the author of 'Index Molluscorum Grœnlandiæ,' was born at Elsinore on the 2nd of November 1810. When he had finished his academical studies his love for conchology took him to South Greenland, the mollusca of which he investigated in company with Captain Holböll from May 1838 to August 1840. After his return to Denmark, he spent several years there in conchologizing and dredging. In April 1843 he made a second voyage to the arctic seas as inspector for the Danish colonies in North Greenland. On his return home in 1844 he went to Italy for his health; but, being seized with a fever at Rome, he died on the 11th of October 1845, at the early age of thirty-five. All his collections were presented by his father, Dr. T. Moller, to the University Museum at Copenhagen.

During his voyage to Greenland in 1843 he made some hauls with the dredge at Fair Isle (which he called Fairhill, in accordance with an old Danish chart); and the result may be of some interest to British conchologists.

The following is a translation of an extract from a letter of his, dated Egedesminde, 6th September 1843:—"I had several times during the voyage opportunities of using my dredge, first in the Cattegat, then between Lindesnes and the Skag, and close to the coast of Norway. On the 19th of May we sighted Fairhill, and the same day Sumburgh Head, where we lay nearly two days dredging, with a calm sea and a beautiful sky. Although the bottom here is exceedingly uneven, and I was in continual fear of losing my dredge, I used my time well, and was fortunate enough not to have any such loss. About two miles† due east of Fairhill, in sixty fathoms, a haul yielded clear shell-sand, with *Cardium echinatum*, *Cyprina Islandica*, and numerous small dead shells. About half a mile nearer Fairhill another haul at about the same depth yielded fine shell-sand, with single valves of *Mactra*, *Venus*, &c. I got four large vessels full of clay and gravel, which gave me constant work until I arrived at Cape Farewell. There were many interesting species; but most of the specimens were injured, I suppose in consequence of the stormy seas which are prevalent in that part."

Möller had himself labelled most of the specimens "Fairhill;" so that there cannot be any doubt in respect of the locality where he procured the species enumerated in the following list. Those species to which an asterisk is prefixed were in a box of shell-sand marked "Fairhill." Some of the species have been determined and named by Mr. Jeffreys, and have the letter (J.) affixed to them.

* See Appendix. † The Danish mile is equal to nearly $4\frac{2}{3}$ English miles.—J. G. J.

ANDROGYNA.

1. *Cylichna cylindracea*. 2. *C.* (*Tornatina*) *mammillata*. 3. *Atys Cranchii*. 4. *Actæon tornatilis*. *5. *Odostomia turrita* (J.). *6. *O. acuta* (J.). *7. *O. diaphana* (J.). 8. *O. spiralis*. 9. *O. acicula*, var. *ventricosa* (J.). 10. *Eulima bilineata* (J.). 11. *Scala Trevelyana*. 12. *S. clathratula*. *13. *Heterofusus Flemingii*. 14. *H. Jeffreysii*.

DIOICA, Latr.

TÆNIOGLOSSATA.

15. *Rissoa parva*. 16. *R.* (*Anoba*) *striata*. 17. *R. soluta* (J.). 18. *R.* (*Alvania*) *punctura*. 19. *R. reticulata* (J.). 20. *R.* (*Alvania*) *Zetlandica*. 21. *R. cimicoides* (J.). 22. *Cyclostrema serpuloides* (J.). 23. *Turritella ungulina* and var. *alba*. 24. *Cerithium metula*. 25. *C. adversum*. 26. *Aporrhais pes pelecani*. 27. *Trichotropis acuminatus*. 28. *Trivia europæa*. 29. *Capulus ungaricus*. 30. *Natica Alderi* (J.). 31. *Velutina heliotoides*.

RHACHIGLOSSATA.

32. *Fusus* (*Neptunea*) *antiquus*, var. *sulcata*. 33. *F.* (*Sipho*) *gracilis*. 34. *Tritonium undatum*, and var. *β ciliatum*, Sow. Ill. Ind. 35. *Nassa incrassata*. 36. *Buccinopsis ovum*. 37. *Columbella nana* (J.). 38. *Pleurotoma costata* (J.). 39. *P. turricula*. 40. *Defrancia linearis* (J.). 41. *D. teres* (J.). 42. *Trophon truncatus* (J.).

EXOCEPHALA, Latr.

*43. *Cyclostrema nitens* (J.). *44. *Trochus occidentalis*. 45. *T. zizyphinus*. 46. *T. millegranus* (J.). 47. *T. tumidus*. 48. *Scissurella crispata*. 49. *Emarginula reticulata*. 50. *Chiton cinereus*. *51. *Dentalium entalis*, young.

ACEPHALA.

52. *Solen pellucidus*. 53. *Psammobia ferroensis*. 54. *Tellina pusilla*. 55. *Macoma calcarea*. An exceedingly fine specimen, nearly 38 in. long, 29 in. lat. The epidermis, ligament, and hinge-teeth are quite perfect. The inside shows traces of soft mud; so that the specimen was probably not taken alive, although it could not have been long dead †. The description given by Chemnitz of *Tellina calcarea* agrees perfectly with this shell; but a species of *Thracia* (probably *T. truncata*) was inadvertently engraved in the plate. 56. *Abra prismatica*. 57. *Mactra solida*, var. *elliptica* (J.). 58. *Venus casina* 59. *V. ovata*. 60. *V. fasciata*, young (J.). 61. *Pullastra virago*. 62. *Goodallia triangularis*. 63. *Astarte danmoniensis*. 64. *Cyprina Islandica*. 65. *Lucina borealis*. 66. *Thyatira flexuosa*. 67. *Montacuta substriata*, on *Spatangus purpureus*. *68. *Kellia suborbicularis*. 69. *Cardium echinatum*. 70. *C. fasciatum* (J.). 71. *Saxicava rugosa*. 72. *Arca tetragona*. 73. *Pectunculus glycimeris*. 74. *Nucula tenuis*. 75. *Crenella decussata*. 76. *Modiolaria discors*. 77. *M. nigra*. 78. *Modiola umbilicata*, Penn. (*M. modiolus*, L., is an East-Indian species). 79. *M. phaseolina*. 80. *Pecten pusio* (J.). 81. *P. opercularis*. 82. *Lima Loscombii*. 83. *L. subauriculata*. 84. *L. elliptica* (J.). 85. *Anomia squamula*.

ECHINODERMATA.

Fragments of a species of *Antedon*.

BRYOZOA.

(Named by Dr. F. A. Smith.)

1. *Lepralia trispinosa*, Johnst. (*L. Jaquenotiana*, Aud.). 2. *L. ciliata*, L. 3. *L. lævis*, Flem. 4. *L. ovalis*, Hassall (= *coccinea*, Abildg.). 5. *L. Malucii*, Aud. 6. *Celleporaria ramulosa*, L. All the above are on *Venus casina*. 7. *Lepralia Peachii*, Johnst., var. *coccinea*. 8. *Membranipora trifolium*, Wood. 9. *M. Pouilleti*, Ald. (*Lepralia Malucii*, Aud.). 10. *Cellepora tubiger*, Busk. All these are on *Pectunculus glycimeris*.

On the future Administration of the Natural-History Collections of the British Museum. By ANDREW MURRAY, *F.L.S.*

The author considered that the announcement of the Chancellor of the Exchequer, that he would, early in the next session of Parliament, submit a scheme for the separation of the Natural-History collections of the British Museum from the Library

† Query? (See Intr. to 'British Conchology,' vol. i. pp. xciv–xcvi.)—J. G. J.

and other collections, as so likely to be carried into effect, that the proper time had arrived for pressing on Government the necessity of some changes in the administration of that institution. The most important of these changes was the transfer of the control of the Museum from the Board of Trustees to a single officer appointed by Government and amenable to Parliament. While admitting the good which the Trustees had done, and that their intentions had always been to benefit the institution, he maintained that the constitution of the Board, composed of men who, with one or two exceptions, felt no interest in natural history, rendered it impossible that they could do it justice. They naturally handed over their power to their chief officers, who were thus invested with power without responsibility and beyond appeal; and although the public had great reason to be satisfied with the services of these officers, there were points on which difference of opinion existed which should not thus be placed beyond the reach of effectual remonstrance. The Board, from the same causes, were slow to alter the existing order of things, or to make the necessary alterations required by change of circumstances and times. He gave the following illustration of this phase of their rule:—When the Museum was young and within manageable bounds, it was placed under one or two head curators, minerals and fossils under one head, and zoology under another. Each of these heads was allowed an assistant, and it was made a rule that these assistants should not be above thirty years of age, the idea being that they should be a sort of apprentices, who should begin young, and, on their respective superior's decease or retirement, be ready to take his place. This rule in itself was not a bad one. It secured always one good man and one learning to become a good man. If the superior officer died before his assistant was qualified to succeed him, it was not essential that the assistant should be put into his place; and as the regulation as to age applied *only to assistants*, it was no barrier in the way of putting an older man in the upper place. But as the collection grew, it was found that more heads were wanted, and then came the error. Instead of appointing new heads coequal with the previous heads for each department, the number of *assistant* curators was increased, and one set apart to each different department, so that each department had, and has now, only one man to it. If any of them die or retire, there is no person to take their work; and being nominally *assistant* curators, although practically head curators, no one can be appointed to their place who is above thirty years of age—in other words, no one who knows his business; for the study of the Natural Sciences is so vast that to constitute youth in such appointments a *sine quâ non*, is really to say that the candidate must be appointed before he has acquired them, and before he has shown any power of acquiring them. The British Museum has thus the unenviable distinction of being the sole place in the whole world where ignorance of a man's duties is not only no impediment to his appointment but a qualification—nay, not only a qualification, but actually a *sine quâ non*. Had the Trustees seen the working of this, they would, instead of appointing assistant curators, have appointed head curators, with such assistant curators as were necessary. And then for each department requiring it we should have had two officers—one a competent, experienced man of position and weight in the scientific world, the other a young assistant, to whose charge ignorance of his duties could not be laid, seeing that his duties were to learn, not to teach. The author considered it plain that we must come back to this original arrangement. These so-called assistant curators, who have long adminstered their respective departments with credit to themselves and the Museum, must be recognized as head curators, and assistant curators, properly so called, supplied to them; while head curators, selected from the best ranks of men of science, should be appointed to those other departments which require them. The author pointed out some of the defects and inequalities in the arrangement of the materials in the Museum—more especially in the Invertebrata. An immense deal had been done in procuring materials, but from want of hands the greatest part of it was practically useless to men of science. He considered that what was now wanted was less of the acquisition of novelties than the utilization of those which the Museum already possessed; and he pressed the importance of establishing, to a much greater extent than has hitherto been done, the system of exchange of duplicates with other museums and individuals which has been found so valuable by other institutions.

On the Nature and Systematic Position of the Graptolitidæ. By Henry Alleyne Nicholson, *D.Sc., M.B., F.G.S.*

The author of this paper, after reviewing the various theories which have been held as to the nature and affinities of the Graptolitidæ, endeavoured to show that they should be referred to the Hydrozoa—a view which he believed was supported by their morphology, development, and reproduction, by their mode of existence, and by the determination of allied forms. The "common canal" of the Graptolite was shown to be strictly analogous to the "cœnosarc" of the Hydrozoa, no similar structure existing in any Bryozoon, whilst the "cellules" found their nearest representative in the "hydrothecæ" of the Sertularians. It was further pointed out that there existed, in several species of the genera *Dichograpsus*, *Tetragrapsus*, and *Diplograpsus*, an organ which had been compared with the basal plate of *Defrancia*, a Bryozoon, by Prof. Huxley, but which was more probably homologous with the "float" or "pneumatophore" of the Physophoridæ, an order of the oceanic Hydrozoa.

As regards their reproduction the author drew attention to the bodies first described by Hall in America and by himself in Britain, and considered to be the "ovarian capsules" of Graptolites. He pointed out, further, the resemblance of these to the "gonophores" of the recent Hydrozoa, both in their shape, and as regarded the changes through which they were observed to pass.

With regard to the mode of existence of the Graptolitidæ, it was shown that by far the majority must have been free and permanently unattached—a fact highly adverse to the belief that they belonged to the Polyzoa.

Lastly, the author noticed the occurrence of a form, originally described by himself under the name of *Corynoides calicularis*, closely allied to the true Graptolites, but apparently representing the order Corynidæ (or Tubularidæ).

In conclusion, the author stated it as his belief that the Graptolitidæ could not be referred to any existing order, or even subclass, of the Hydrozoa, but that they stood in the same relation to existing forms that the Trilobites hold to the recent Crustacea. In their mode of growth, in the arrangement of their parts, and in the nature of their structural elements they were seen to resemble the Hydroid polypes; but they were widely separated by their free "hydrosoma." On the other hand, they approximated to the oceanic Hydrozoa in the fact that they were free-floating organisms, and in the possession, by some forms, of an organ resembling a "float." On the whole the author was of opinion that the Graptolitidæ should be held to constitute a new subclass intermediate in position between the fixed and the oceanic Hydrozoa, and that they might possibly, on the derivative theory of development, be looked upon as the primitive stock from which the above existing sections of our living Hydrozoa had originally diverged.

On the Fructification of Griffithsia corallina, *found in the West Voe, Outskerries, Shetland. By* C. W. Peach.

In May 1864, when in Shetland with Mr. J. G. Jeffreys on a dredging excursion, Miss Jeffreys found some fine specimens of *Griffithsia corallina*, which, on examination, the author found in fruit and in fine condition. Under the microscope he observed a circular opening in the lower part of the joint above the fruit (tetraspores), from which opening the granular pulp of the joint was poured on the fruit under it. Harvey, in his introduction to his 'British Marine Algæ,' gives a long account of the fructification; but there is nothing in it that fully agrees with the above.

On Naked-eyed Medusæ found at Peterhead and Wick, N.B., and other British Localities. By C. W. Peach.

The author first stated that during his residence in Edinburgh he had opportunities of examining books not before accessible to him; by these he found that many of the naked-eyed medusæ that he had found were new to the British list. He then described one he got in Cornwall in 1849, which he thought was *Willsia stellata* of Forbes, but after careful examination, and comparing it with others, is satisfied that it is a new species, and has named it *Willsia Cornubica*; it has only

twelve tentacles. His next new one is a *Tima*, which he has named *Tima Forbesii*, in memory of the late Professor E. Forbes; the principal difference between it and *Tima Bairdii* is that instead of having only sixteen tentacles, in it they are numerous. Several others came in for their share of notice, and then he mentioned *Goodsirea mirabilis*, a new genus founded by Dr. T. Strethill Wright, and published by him in the second volume of the Transactions of the Royal Physical Society of Edinburgh. The author got this specimen at Peterhead in 1851. He fully confirmed Dr. Wright's observations, and added that some of his specimens had two additional, but shorter tentacles than Dr. Wright's; he thought this only a sexual difference. He then described what he considered the most curious of all he had seen, a new genus (*Staurophora*) to the British shores, and the largest naked-eyed Medusa hitherto noticed in our seas. It was first found in the Pacific by Mertens when on a voyage round the world; since found by Agassiz in Boston Bay, America, in 1849, and was described by him in a paper entitled "Contributions to the Natural History of the *Acalephæ* of North America." The umbrella is crossed by four gastrovascular canals; from each of them hang two curtain-like masses; and, to appearance, it has neither mouth nor stomach. However, by parting the curtains both are to be seen. He described it at great length, and stated that he got it off Peterhead several times in 1851, and that it grew from $\frac{5}{8}$ in. in breadth to $3\frac{7}{8}$ in. in breadth between May and June. He has named it *Staurophora Keithii*, to mark his respect for the founder of Marischal College, Aberdeen, it having been first found near Keith Inch, Peterhead, once the property of the unfortunate house of Keith.

On the Zoological Aspects of the Grouse-disease.
By the Rev. H. B. Tristram, *M.A., F.R.S.*

The rapid extension and epidemic character of the grouse-disease was attributed in great measure to the indiscriminate slaughter of predatory animals. These, it was true, destroyed game, but it was only the weakest and the most diseased animals that they could make a prey of. In this way disease was stamped out, as had been artificially done with the cattle plague. He commented severely on the encouragement given by landed proprietors to the destruction of wild animals, complaining that upon this question game-preservers were more open to be influenced by ignorant gamekeepers than by naturalists. The grouse-disease had existed sporadically for at least two years before it was generally noticed.

On Birds' Nests and their Plumage; or the Relation between Sexual Differences of Colour and the Mode of Nidification in Birds. By Alfred R. Wallace, *F.R.G.S., F.L.S.*

The author pointed out the hitherto unnoticed fact, that whenever female birds resembled the males in being adorned with gay and conspicuous colours, their nests were so placed or so constructed as to conceal the sitting bird. He showed that this generalization was supported by a vast number of facts in all the chief groups of birds, while the exceptions were few and unimportant, and concluded by pointing out its correspondence with the general principle of protection in modifying colour, and by arguing that the whole of the phenomena could be well explained on the theory of the preservation of useful variations.

Anatomy and Physiology.

On Protagon in relation to the Molecular Theory of Organization.
By Prof. Hughes Bennett, *M.D., F.R.S.E., of Edinburgh.*

The author pointed out that the progress of scientific discovery tended singularly to confirm the truth of the molecular theory of organization, which he had first laid before the Association at its Meeting in Glasgow twelve years ago*. The

* Report of the British Association, 1855, p. 119.

formation of a substance, named protagon, from the oleo-albuminous matter of the egg, by the action of alcohol, had recently been shown by Dr. Montgomery to be capable of enabling us to make out of its substance, artificially, on a glass slide, most of the elementary textures of animal bodies. The author had repeated Dr. Montgomery's experiments with protagon, and placed upon the table a large number of preparations, exhibiting organic forms and textures thus constructed. He regretted that neither the time nor the arrangements of the Section were of a kind which would enable the histologists present to examine them. He had displayed one preparation under the microscope, however, which he believed to be unique, as it demonstrated that molecules possessed in themselves the power of arranging themselves into nucleated cell-forms, without any previous cell-formations.

The first step in the line of discovery which indicated the physical conditions necessary for the formation of animal and vital textures was, in his opinion, made by Ascherson in 1840, who showed how the mere contact of oil and albumen produced a molecular membrane called haptogen membrane. The second step was the determination by Rainey of the influence of viscidity and limpidity in liquids, causing in them the precipitation of globular and crystalline forms. A third step consisted in demonstrating the difficulty with which these viscous or colloid substances pass through membranes, as compared with liquids, for which we are indebted to the researches of Graham. A fourth step he considered was the demonstration that the diaphanous or hyaline bodies, so long known to histologists, consisted of a glutinous substance formed in cells, which could be squeezed out of them by pressure, as lately shown by the author *. Lastly, the experiments with protagon by Montgomery † had shown that this peculiar viscous material, when mingled with water, albumen, glycerine, serum, or other substances, and acted upon by acetic or nitric acids, could be made to assume the form of fibres, varicose tubes, nucleated cells (simple and compound), pus-corpuscles, and bodies which, like salivary cells, exhibited numerous granules in their interior, possessing active molecular movements. All these researches tended to clear up the nature of a multitude of facts, long known to histologists, to several of which Dr. Bennett referred, and which had led him to the following conclusions :—

1. That our present knowledge of the physical conditions necessary for the formation of elementary structures indicates the vast importance of studying the relations, chemical, mechanical, and structural, of the fatty, albuminous, and mineral constituents of the animal frame.

2. That the constant formative and disintegrative processes occurring among these constituents is largely due to chemical and mechanical action, especially pressure and friction.

3. That the differentiation between these elements is also attributable to the physical properties of viscidity and limpidity, the former tending to produce globular, and the latter linear or crystalline forms.

4. That these viscous and limpid fluids exist in the living body, are constantly influenced by mixture, pressure, and endosmose, and may frequently be seen, especially in morbid products, to originate formation by molecular deposition, and so-called nuclei, cells, and fibres by molecular aggregation.

5. That these facts throw great light upon the circumstances necessary for the production of elementary structures, but leave our conception of vital properties and of vital tendencies pretty much as it was, viz. unknown powers inherent in the tissues generally, determining their development and regulating their action.

New Investigations to determine the Amount of Bile secreted by the Liver, and how far this is influenced by Mercurials. By Prof. Hughes Bennett, *M.D., F.R.S.E. &c.*

The author stated that, although much had been written regarding the functions of the liver, and the action upon it of mercurials, very little exact information existed on the subject. Last winter a Committee had been formed in Edinburgh to reinvestigate the amount of bile secreted in health, and how far such

* Journal of Anatomy and Physiology, 1867, p. 322.

† On the Formation of so-called Cells &c. London, Churchill, 1867.

secretion was influenced by mercury. It was composed of Profs. Christison and Maclagan, of the Edinburgh University, Dr. James Rogers, formerly of St. Petersburgh, Drs. Rutherford, Gamgee, and Fraser, Assistants in the Edinburgh University, and of Prof. Bennett, the Chairman and Reporter.

After studying all that had been previously published by authors (an able Report on which had been furnished by Dr. Rogers), the Committee first took into consideration what method it was best for them to pursue. It was then pointed out by Dr. Gamgee that, in the opinion of modern chemists, no kind of examination of the fæces could yield trustworthy results. Supposing that the chief and characteristic constituents of the bile found their way into the fæces unchanged, imperfections in the analytical methods at our disposal rendered its quantitative analysis impossible. The plan of ascertaining the amount of bile-acids indirectly by means of nitrogen and sulphur determinations of the alcoholic extract, while most unsatisfactory in the case of pure bile, is still more so when applied to the alcoholic extract of fæces. The method of Hoppe-Seyler of Tubingen, who calculated the amount of bile-acids from the effect which their solutions exert upon a ray of polarized light, presents such complexity and difficulty as to render its systematic employment in any series of analyses altogether inapplicable. As to the colouring-matters of bile, there is no direct method known by which they can be estimated. It was further argued that, did we even possess means of estimating the bile products, it is only a small portion of such as are secreted by the liver which can be found in the alvine discharges. Bidder and Schmidt ascertained that the amount of unoxidized sulphur in them only represented one-eighth part of the total sulphur which the liver secretes, and that of the other constituents of the bile the larger proportion are absorbed. That under the influence of purgatives unchanged bile is occasionally discharged from the bowel, is true, but this furnishes no proof of any increase of that secretion; for under ordinary circumstances it is decomposed and absorbed in the alimentary canal, and any cause which increases the rapidity of its passage there must render absorption and decomposition less complete. These arguments convinced the Committee that no accurate information as to the amount of bile secreted by the liver was to be obtained by an examination of the fæces. They therefore resolved that the collection of bile directly through artificial fistulæ made with the gall-bladder was the only means open to them of determining how far mercury influenced that secretion.

Prof. Bennett then described the efforts made to establish fistulæ in fourteen dogs, and the apparatus which had been constructed to collect the bile and prevent its being disturbed by the animal. The investigations were carefully conducted by Dr. W. Rutherford and Dr. Gamgee, occasionally assisted by Dr. Fraser, and superintended by the Committee. He gave, in a tabular form, the results of four series of experiments to determine the amount of bile secreted without and with mercury. It was soon observed that the amount of bile obtained varied greatly from day to day, irrespective of the amount of food and drink given, or any other known circumstance. This pointed out a serious fallacy in the observations of previous experimenters, who had been satisfied with estimating the amount of bile formed by collecting it for a few hours, or at most for one or two days. In each series of experiments, an average of the collections was taken for six entire days, first without and then with mercury, and the quantities obtained were calculated so as to determine the amount of bile as compared with each kilogramme of the dog's weight and each kilogramme of the dog's food. In many important respects the results obtained differed from those of previous investigators. It is unnecessary to reproduce the tables and observations made in this abstract, because it was pointed out that further researches were required before so difficult and intricate a subject could be sufficiently investigated to warrant the formation of conclusions. All that need be stated at present is, that in the experiments hitherto made, mercury had not caused any sensible effects either upon the biliary or urinary secretions. The author concluded by observing that, should the Section consider the researches of the Committee so far deserving of encouragement as to be assisted by a small grant from the funds of the Association, he hoped to be enabled to report more definite results next year.

On the Epithelium of the Cornea of the Ox in relation to the Growth of Stratified Epithelium. *By* Professor CLELAND, *M.D.*

In this communication evidence was brought forward to show that in the epithelium of the cornea the cells of the deepest stratum, which are columnar, degenerate and disappear without becoming more superficial. It was pointed out that next to these columnar cells were others of greater breadth sending in processes between them, and that superficial to these were small cells, many of them with two nuclei, and likewise many free nuclei, and that beyond this stratum the cells became gradually larger, flatter, and more solid the nearer they were to the free surface. In conclusion it was pointed out that although the circumstances of nutrition in the case of the corneal epithelium were too singular to permit our safely assuming that other stratified epithelia grew in the same manner, yet the facts brought forward were sufficient to show that in these structures the deepest cells were not necessarily the youngest, and that cells might be removed from them by other means besides passing to the surface.

On some Points connected with the Joints and Ligaments of the Hand. *By* Professor CLELAND, *M.D.*

The following were the principal points brought forward:—

In flexion and extension of the wrist the semilunar bone slides backwards and forwards between the scaphoid and cuneiform; and in over-extension of the wrist it is supported by two ligaments, which descend and converge to be attached on its palmar surface, precisely according to the principle by means of which the sacrum is suspended between the haunch-bones.

In the metacarpo-phalangeal articulations lateral movement is prevented in flexion while it is allowed in extension, by the lateral ligaments taking origin from points nearer the extremity than the front of the metacarpal bone, and by the distal ends of the metacarpal bones being much broader in front than behind, so that the lateral ligaments are stretched over the broad part in flexion. The arrangement gives strength in grasping.

Strong ligaments, hitherto undescribed, extend from the sides of the phalanges near the phalangeal articulations, and are inserted into the skin, helping to retain the different parts of the integument in the positions which they are adapted to occupy.

Microscopical Preparation of the Nerves of the Cornea. *By* Professor CLELAND, *M.D.*

This preparation, which consisted of a considerable portion of the superficial layers of the cornea of a sheep, exhibited a perfect network continued from nerves all of which entered at the periphery. The cords of the network, although placed at slightly varying levels, united to form a single stratum; they appeared to consist each of several fibres. No terminations of nerves could be seen, nor any fibres given off from the network, either to the surface or deep parts of the cornea.

On a new form of Cephalopodous Ova. *By* Dr. COLLINGWOOD, *M.A.*, *F.L.S.*

This paper was a description, accompanied by drawings, of a remarkable body, found in the North Atlantic Ocean, consisting of a large number of ova imbedded in a transparent jelly resembling frog's spawn, and floating freely in the sea. The ova proved, on examination, to be those of some species of Cephalopod, but different in character from any other known form. The author compared it with the described forms deposited by *Octopus*, *Sepia*, *Sepioteuthus*, *Loligo*, &c., to none of which it bore any resemblance; and he exhibited microscopic drawings of the young Cephalopods in various stages of development.

On the Influence of Atmospheric Air on Vital Action as tested by the Air-pump. *By* JOHN DAVY, *M.D.*, *F.R.S.*

In this paper the author described a certain number of experiments, the results of which showed how much longer some animals are capable of resisting privation

of air than others. Thus, in one instance, an egg, an inchoate animal, so to speak, was hatched, producing a healthy chicken, after having been acted on by the air-pump 26 days,—a young bird expiring in about half a minute, a fish, the minnow, in about an hour; the frog and toad in about the same time; the earthworm in about an hour and a half; insects, such as the bee, dragonfly, and butterfly, after apparent death for more than an hour, recovering on exposure to the air, and that repeatedly.

By other experiments on birds by means of submersion in water, he showed that different species varied greatly in ability to bear exclusion of air: thus, while all the small birds of which he had made trial expired under water in a minute or less, the buzzard lived about two minutes and a half; the common fowl about four minutes and a half; the goose and duck about ten minutes.

Reasoning on the results, he infers that each individual animal has something peculiar in its organization, determining its peculiarities of function or action—peculiarities more readily described than accounted for. He holds the subject to be, in a great measure, mysterious; nor is he sanguine, referring to the new and ingenious views relative to the genesis of species, that they will tend, except partially, to enlighten the subject, considering that life itself is a mystery, and the origination of life, as regards natural science, an unsolved problem.

On the Phenomena of Life and Mind. By Robert Dunn.

Vocal and other Influences upon Mankind, from Pendency of the Epiglottis. By George Duncan Gibb, M.A., M.D., LL.D.

The author gave the results of his examination with the laryngoscope of 4600 healthy persons, of all ages, both sexes, and varying positions of life, which showed that in 513 the epiglottis was found to be quite pendent, in place of a vertical position. He determined that this was hereditary in many instances, for it was found in the mother and her child. This made the percentage to be 11 amongst Europeans; but it was found to be much greater in the natives of Asia and Africa, 280 of whom he had examined. The influences observed in Europeans were a modification of the natural voice, which tended towards a bass tone in adult males; the singing voice was materially altered, and in the female sex the higher notes could not be produced at all in some persons, whilst in others it weakened their vocal power and compass. The author had never known a great female singer to possess a pendent epiglottis. He contrasted the direction of the voice in cases of erect and pendent epiglottis; in the latter the voice strikes the back of the throat, *behind*, instead of in front of, the soft palate. Young girls with pendency can never expect to become singers of any note unless it be remedied, and in them, and in boys too, the voice is not clear and silvery as it ought to be. Certain constitutional peculiarities were also noticed, and there was a predisposition to contract the exanthemata and other diseases of an epidemic nature. The author concluded by referring to the large number of pendencies in Britain, over 3,000,000, and the means to be taken to remedy it.

Observations with the Spectroscope on Animal Substances. By E. Ray Lankester.

By means of dark bands produced in the prismatic spectrum (when light is transmitted through coloured solutions) it has been shown, by Hoppe-Seyler and by Prof. Stokes, of Cambridge, that various coloured bodies may be definitely recognized. Mr. Sorby has also made many observations of vegetable colours, and invented a very convenient form of spectroscope. The author's observations were made upon various coloured substances in the lower animals; by this means he had detected chlorophyl in *Hydra* and the freshwater *Spongilla*, which had before been suspected to be present, but of which there was no certainty. In various worms (*Eunice*, *Lumbricus*, *Hirudo*), in an insect-larva (*Chironomus*), and in a mollusk (*Planorbis*) he had found the same red substance (cruorine) discovered by Stokes in the blood of man and vertebrates. This was remarkable, since the red matter was deficient in nearly all mollusks and insects; and, moreover, in vertebrates it was

concentrated into red corpuscles, which was not the case with invertebrates. A new green blood-colouring-matter was described by its spectrum, found in the blood of some annelids (*Siphonostoma*). A large number of orange, red, green, and yellow pigments were obtained in solution by ether, from marine Sponges, Polyzoa, Crustacea, and other animals; but none of these had given definite absorption-bands by which they could be recognized and characterized. It appeared that mere pigments did not present the phenomenon, whilst other bodies not of a *fatty* nature did. It was very desirable that further observations should be made with the spectroscope on animal substances.

Nouvelle comparaison des membres pelviers et thoraciques chez l'Homme, les Mammifères, les Oiseaux et les Reptiles déduite de la torsion de l'humerus. Par CHARLES MARTINS*.

Life—its Nature, Origin, &c. By P. MELVILLE.

Notes of Experiments with Poisons &c. on Young Salmon. By DR. M'INTOSH.

These experiments were performed in 1862 and 1863 on newly hatched fish, which, from their transparency, are very favourable subjects. The most numerous were those with Flem. tinct. of aconite, which at first caused symptoms of irritation, with twitchings and considerable muscular movement. The heart's action by-and-by became irregular, and then a remarkable tendency to more rapid motion of the auricle appeared, with a slowing of the ventricular action, and the latter became more marked as the paralysis of the muscles generally increased. Under the action of this poison some very interesting observations may be made on the heart's action; and from the non-rhythmical movements of the cavities, a halt was now and then caused by the contractions occurring at the same time. The general result was that the auricle contracted twice for each ventricular action. This condition was independent of the respiratory process. Other drugs experimented with were tinct. digitalis, creosote, sulphuric ether, chloric ether, morphia, chloroform, bleaching-powder, ammonia, &c. A few minims of a solution of bleaching-powder proved rapidly fatal; and though the fish was placed under running water in a few minutes, and before motion ceased, it did not recover. Muscular irritability and convulsive movements continued for about a minute after the heart's action had ceased under chloroform. Considerable vitality was exhibited when the fish was placed in sea-water, death ensuing slowly from cardiac congestion caused by the shrivelling of the superficial textures, and consequent shutting up of the blood-channels; and secondly, from a peculiar coagulation and hardening of the yelk-sac and the resulting interference with nutrition. The tentacles of an anemone (*Tealia crassicornis*) did not appear to exert a poisonous or paralyzing action, but the young fish died slowly from the physical injuries inflicted by the dart-cells. Regeneration of artificial wounds rapidly ensued, and when the tip of the tail was cut off some curious effects were observed in regard to the clot which formed at the tip of the artery.

On the Adaptation of the Structure of the Shell of the Bird's Egg to the Function of Respiration. By DR. G. OGILVIE.

The principal object of this paper was to call attention to the constant occurrence of a cavernous stratum on the interior of the shell of the egg, formed by a series of warty excrescences from the calcareous crust, and covered in by the lining membrane of the shell, which adheres so intimately to the points of the tubercles that a fleecy film is always left when the membrane is torn off from the inside of the shell, and in many cases can be removed only by burning it off by calcination, though the nature of the structure may be shown in other ways, as by sections and the use of aniline dyes, which tinge the fibrous tissue, with little or no effect on the shell proper. The penetration of the external air into the cavernous structure, through the overlying stratum of the calcareous crust, is facilitated by the pore-like pits on the outside of the shell, which, though in many cases they do not go directly

* See Appendix.

much below the surface, yet may be shown, by the permeation of coloured liquids, to furnish an indirect communication with the vacuities of the deep layer, either by fissures or cracks passing between them, or by the more pervious nature of the intervening tract. This general arrangement of an upper compact and a lower cavernous stratum has a certain analogy with the structure of the internal tissue of leaves, amounting, indeed, in some cases to so close a resemblance that one might readily compare the shell of some chelonian reptiles to the parenchyma of a leaf which had undergone calcification; and as in the egg-shell we have the pore-like pits on the outer surface to facilitate the permeation of the air to the subjacent stratum, so in floating leaves, which have their stomata on the upper epidermis, we generally have some arrangement to lessen the obstructive influence of the layer of compact tissue between them and the spongy parenchyma below. Of this perhaps we have the most striking example in the large tapering cells in the leaf of the White Water Lily, which, when exposed to the action of an aniline dye, become very conspicuous objects from the readiness with which they take in the colour; they somewhat resemble a series of nails driven through the compact tissue, with their flattened heads immediately under the stomata, and their points projecting into the air-spaces below. As another example of such an arrangement, reference was made to the vacuity under each stomatic opening in the upper layer of parenchyma in the leaf of the common pond-weed.

On the Antiseptic Properties of the Sulphites. By Dr. Polli, *of Milan.*

Sulphurous acid was said to be the most active agent in arresting all organic fermentation. As the acid, however, was not easily applicable in experiment, Dr. Polli had undertaken an investigation as to the action of the sulphites of lime, hyposulphite of magnesia, sulphite of magnesia, and sulphite of soda. These substances were found to possess all the properties of sulphurous acid, with the advantage that their action was more uniform and certain and constant. In experimenting on animals and himself, he found that large doses could be taken without risk. On killing animals treated with sulphites, and others not so treated, he found that the former were most slow to decompose, and, indeed, remained quite fresh when the others were putrescent and offensive. Another series of experiments showed that in one class the administration of the sulphites was sufficient to effect a more or less rapid cure in cases where blood-poisoning was present, as in fevers. Dr. Polli was anxious to have it clearly stated that he did not attribute this to any curative power in the sulphites, but to the fact that they arrested decomposition, and by so doing allowed the animal to recover by the recuperative power existing in its own constitution. The author thought his observations conclusive as to the excellent influence of the sulphites on certain diseases.

On Coagulation of the Blood—a correction of the Ammonia Theory. By Dr. W. B. Richardson.

On some Effects produced by applying Extreme Cold to certain parts of the Nervous System. By Dr. W. B. Richardson.

On certain Effects of the Concentrated Solar Rays upon the Tissues of Living Animals immersed in Water. By George Robinson, *M.D.*

After adverting to the wonderful effects of the composite nature of the solar rays, and to the circumstance that water of all fluids next to the air is the medium most intimately connected with animal and vegetable life, the author gives an account of the effects he has observed when he has concentrated the solar rays on numerous bodies immersed in water.

The most remarkable results were those obtained in experimenting on small fishes and frogs. To the former the action of the rays, when concentrated upon the head, was immediately fatal; of the latter the skin was shrivelled and discoloured. Even on his own hand the effect was immediately perceptible, pain followed by inflammation.

He concluded with remarking, "It would therefore, from this particular rela-

tion, appear that the nervous structures of living animals are peculiarly sensitive to the stimulating agencies present in the solar rays, irrespective of the actual heat of the latter; and it is thus rendered probable that it is not the calorific element of those rays that produces the effects witnessed in my experiments. Whether or not their actinic or chemical part chiefly operates in these cases, or whether another active power nearly allied to electricity, or the nervous force itself, is really contained in the sun's rays, must be left for further research."

On the Presence of Quinine and other Alkaloids in the Animal Economy. *By* WENTWORTH L. SCOTT.

Professor ALLEN THOMSON exhibited microscopical preparations of the Cochlea, of the Retina, and of Teeth of Fossil Fishes.

A Contribution to the Anatomy of the Pilot Whale (Globiocephalus svineval). *By* Prof. TURNER.

Two innominate arteries arose from the transverse part of the arch of the aorta; the right bifurcated, and by one branch gave origin to the carotis cerebralis, carotis facialis, and subclavian arteries, by the other to the cervico-occipitalis and the art. thoracica posterior dextra. The left innominate gave origin to a small thyroid artery and then bifurcated: its anterior branch divided into carotis facialis and subclavia sinistra; its posterior branch into carotis cerebralis and cervico-occipitalis. The art. thoracica post. sinistra arose from the back of the arch close to its junction with the ductus arteriosus. The cerebral carotids diminished very much in size before entering the skull, as Sharpey and Von Baer had already shown in the porpoise. The weight of the brain was 58 oz., and the amount of blood conveyed to it by these arteries was much less than in the adult human brain, so that the functional activity is necessarily slower than in the brain of Man.

The stomach was subdivided into five compartments: the 1st and 2nd communicated with the bottom of the œsophagus, and along with the 3rd corresponded to the first three subdivisions of the stomach of the porpoise. The 4th compartment in the Pilot Whale is not differentiated in the porpoise, but the 5th compartment corresponds to the 4th or sigmoid stomach of the porpoise. Between it and the cylindrical duodenum was a dilatation, which differed from the dilated commencement of the duodenum in the porpoise in not having the hepatico-pancreatic duct opening into it.

These and other details are given much more fully in the 'Journal of Anatomy and Physiology,' November 1867.

Microscopic preparations in illustration of the ultimate arrangement of the bile-passages and of the minute anatomy of the nervous system were exhibited by Prof. Turner. The preparations were made by Mr. A. B. Stirling, Assistant in the Anatomical Museum, University of Edinburgh. The sections of the liver, from the rabbit, served to confirm the recent views of Hering and others, that the bile passes to the periphery of the lobules in channels, which lie between and have their walls formed by the liver-cells, and which communicate with the interlobular branches of the hepatic duct.

GEOGRAPHY AND ETHNOLOGY.

Address by Sir SAMUEL BAKER, *F.R.G.S., President of the Section.*

Two years have elapsed since, in the month of September 1865, jaded with the anxiety and fatigue of nearly five years' exploration, I and the devoted companion of my journey—my wife—returned to civilization from a land of savages, from the

Albert N'yanza; and we rejoiced that, in conjunction with the discoveries of Speke and Grant, we had secured for England the merit of the discovery of the Nile-sources. . . . I have received many rewards for this long period of trial and difficulty in African research,—the approbation of Her Majesty, the gold medals of the Royal Geographical Societies of both England and France, and the cordial reception of the account of our travels given in the 'Albert N'yanza Great Basin of the Nile;' but believe me when I assure you that I esteem as one of the highest honours the compliment that has been bestowed by the British Association, by their invitation that I should occupy the position of President of their geographical section.

When I look upon my right hand and upon my left, and find myself supported by those veterans of science and of industry, by those men whose heads have grown grey in the pursuit of knowledge, and whose intellects, enriched by the experience of a long life, we regard with reverence and esteem, I feel with much humility that I am a usurper of the Presidential chair which has been so ably and so honourably filled by Sir Roderick Murchison and by Mr. Crawfurd, the time-honoured Presidents of the Royal Geographical and the Ethnological Societies.

But, as the younger trees grow up beneath the branches of the venerable oaks and prosper in their shade, even so I venture to rise between my much-honoured supporters, and recall to recollection the important fact that the high and prominent position now held by the geographical section in the proceedings of the British Association is due to the labour and untiring energy of Sir Roderick Murchison, to whom belongs the merit of having given to Geography an independent place in the Meetings of this general parliament of science.

Geography is worthy of this high position, as nearly every science is dependent upon our knowledge of the earth.

Astronomy would afford meagre results were we ignorant of the spherical form of our world, and were our observations confined to our own cloudy shores; but our observations are directed from stations in all positions on the globe, the knowledge of those positions being due to our first explorers.

Ethnology is a twin sister of geographical science, as the numerous races of human beings (so diverse and inexplicable) that inhabit the various portions of the earth, from the ice-bound regions of the Arctic to the burning deserts of Africa, would have been unknown but for the researches of geographers and explorers.

Theology is closely interwoven with the study of geography; the history of man from the remote beginning is linked with a description of the creation of the world, when God said, "Let us make man in our own image." From that time the very elements of our creed are connected with particular positions upon the earth's surface. The most important events that have influenced the march of civilization and the spread of Christianity have occurred in certain places that throw intense interest upon the science of geography. The wanderings of certain nomadic tribes seeking for new pastures for their flocks have brought to light new countries, and have implanted new religions. The arrival from Chaldea of Abraham, the simple Arab chieftain with his followers who settled in a new country, laid the foundation of our Jewish history, followed by those mighty events at distant intervals, the Exodus from Egypt, the building of Jerusalem, the birth of Christ, the Roman conquest, until at length, by the victories of Cæsar, the West was rescued from its savagedom, and the road was opened to Great Britain, to be followed by the light of truth. All this wonderful train of progression is based on geography; and, as St. Paul with untiring zeal journeyed often "in perils of waters, in perils of robbers, in perils by the heathen, in perils in the wilderness, in weariness and painfulness, in hunger and thirst, in cold and nakedness," even so the missionary and the explorer have united in patiently boring their way through lands that have lain hidden since the world's creation; and these countries have risen to the first rank in the earth's history. Far-distant lands, tenanted by savage races that knew no God, rescued from a state of barrenness, are smiling with prosperity; the wild beasts and the heathen have retreated before advancing civilization, and the sound of the church-bell rings at our very antipodes. Thus is religion linked with the study of the earth. The advancement of Christianity is dependent upon the migrations of Christians that shall implant the seed of truth in foreign soils. Those migrations

are dependent upon geographical discoveries that shall bring to light countries and climates favourable to the development of European races. Thus civilization will advance to a higher standard in such latitudes as are conducive to industry and enterprise; the severity of an Arctic region would be as great a barrier to the intellectual progress of the inhabitants as would the burning sun and barren sand of the desert where Nature has withheld every blessing from mankind. In such localities the human energies are overpowered by the oppression of circumstances, and a high standard of civilization can never be attained. If, therefore, civilization be mainly dependent upon temperature and geographical position, it will be exhibited in the highest degree within particular latitudes comprised in the temperate zone. The discovery of countries that afford the requisite conditions for such advancement has been the grandest result of comparatively modern geography. In tracing the progress of geographical science from the earliest period of history, we are struck with the marvellous strides effected during the last three centuries.

When we consider that the Mosaical history accounts for 4004 years from the creation of the first man until the birth of Christ, and thus establishes the *recorded* existence of man for a period of 5871 years to the present day, we must regard with the most intense interest the mysterious development of the world during that space of time.

The Phœnicians were the most ancient maritime power described in history, the ports of Tyre and Sidon having been their London and Liverpool. Even at the remote date when Pharoah Necho governed Egypt, the Phœnicians are said to have circumnavigated Africa, having passed through a canal from the Mediterranean to the Red Sea, and returned to Egypt by the Straits of Gibraltar. Thus was mysterious Africa sailed around at that remote age,—an object of barren wonder to the mariners, who were amazed to find the rising sun upon their right hand instead of on their left upon rounding the Cape of Good Hope from the east and coasting north.

The Phœnicians are supposed to have traded with England, and to have obtained tin from Cornwall; they founded Carthage, which subsequently gave birth to the adventurous explorer Hanno, who coasted the western shores of Africa to near the Equator.

In those days the principal objects of exploration were commerce and conquest: there was no Royal Geographical Society, with a Murchison as President, to support the love of science and adventure; but the report of the explorer, if successful, was, as in the case of Cæsar, *Veni, vidi, vici*!

The voyages of the ancients were generally confined to coasting or to crossing narrow seas by the guidance of the stars, in precisely the same manner as performed at the present day by the Arabs in navigating the Persian Gulf and the Red Sea. There can be little doubt that they were acquainted with India and Ceylon, as the presents of peacocks to Solomon must have been brought from one of those countries, that species of bird being unknown in Africa. The conquests of Alexander extended geographical knowledge into the far interior of India; and the founding of Alexandria added an important seaport to the Mediterranean.

Although the enterprise of the Greeks and the Phœnicians had overcome the difficulties of the Mediterranean, and had established trading-stations upon the east coast of Africa, their explorations were bounded by that impassable barrier to the west—the mysterious Atlantic Ocean. They had visited Zanzibar, and doubtless they had penetrated far into the interior of Eastern Africa, and had heard of the existence of the great lakes which Ptolemy long afterwards placed upon his map, from the description of native merchants, as the sources of the Nile; but from the beginning of the world up to the fifteenth century, no human eye had pierced the mystery of the Atlantic. At that time there were two great geographical questions to be solved—the Nile and the Atlantic.

The fifteenth century was rich in geographical discovery. Marco Polo's travels in Asia had brought renown to Venice; and Vasco de Gama had, by the circumnavigation of Africa, sustained the honour of Portugal, which enterprising country assumed the lead in exploration, until Columbus achieved the feat that completely altered the geography of his age—the discovery of America. How little did he dream that, within the short interval of three and a half centuries, the New World

that he had discovered would be able to defy the Old!—that upon the waves which rocked the frail canoes, iron-clads would fly the stars and stripes, that a vast nation of Christian men should spring from the new soil and people the desolate wastes, that the wilderness should become a garden and the swamps luxuriant cotton-fields, that great cities should arise upon the margin of her rivers, that the slave should be rendered free, and that the electric spark should speak in the profound depths of the Atlantic and hold communication each minute with the West! —that weary distant West, to which for weeks and weeks he had struggled on towards unknown shores, lost on a boundless ocean, but trusting in a Divine Guide who watched over the human instrument that steered onwards on the grand path to civilization.

In the short period of 380 years, a small fractional portion of the interval assigned to the existence of man upon our earth, what vast changes have occurred, not only in geographical discovery, but by its results! America has become a giant, an irresistible power upon her own soil, separated from Europe by an ocean that renders her secure from hostile aggression. With every variety of climate, from the frigid to the torrid zone, with fertile soil, boundless forests, navigable rivers of prodigious extent, and commodious ports, the future of that wonderful country may be prognosticated by a comparison with the past. The first steps of a young colony are slow and full of difficulty; but if in 380 years America has attained her present high position from an utterly savage state, what part will that vast continent assume in the future history of the world?

If possible, more wonderful in rapid advancement than America is that extraordinary country beneath our very feet. Australia is an instance affording a practical result of that wide theory, that temperature and geographical position are the channels of civilization, and that according to the conditions of climate and the advantages of a locality will be its degree in the scale of progress. Within the memory of many who are here present, the now important cities of Australia were mere buds upon the family tree of colonies. Blessed with the favourable conditions of temperature and geographical position, they have burst suddenly into bloom. Not only have we that vast pyramid of gold exposed in the Paris Exhibition as proof of the value of Australia, but we possess a more lasting testimony of the importance of that fifth section of the globe in the imports of *wool* of the finest quality. This is the most complete proof of success, as the locality most favourable to the fine-wool-bearing species of sheep is that most specially adapted for the European races of mankind.

We have thus two grand examples before us of the energy and vitality of the Anglo-Saxon race. Great Britain, that at the time of the Roman conquest was an island of half-naked savages, whose explorations were confined to coasting their own shores in hide and wicker-work canoes, has in the course of ages fulfilled her great destiny, and is become the parent of the East and West. Australia and America are the two huge children of the old mother, grand offsprings from which must flow the sources of civilization.

But in the moment of triumph, when we regard these mighty results of geographical enterprise with pride and satisfaction, geography, that all-important science which we have now the honour to represent, whispers this warning in our ears—"That as we have peopled distant lands, and nursed these infants until they have become great, the mother should no longer hold them in the leading-strings of childhood, but that, as stalwart sons grown into manhood launch independently upon the world, so should our great offsprings, Canada and Australia, regard the old mother with affection, but assume their position of independence." Geography is the base of diplomacy. There are things difficult, but possible; but there are obstacles of Nature that are impossible to overcome. The Atlantic declares the independence of Canada, as no support could be afforded by Great Britain in a contest with America.

It is natural to our insular position that geographical science should be more deeply appreciated in England than in other countries. Our strength lies in our commercial enterprise. Our commerce depends upon our colonies; these encircle the world. Thus geographical knowledge must be an important element in English education, as hardly a family exists in the United Kingdom that is not represented by one or more of its members either in India or the colonies.

There are at the present day important questions connected with our Indian possessions that demand the vigorous attention of English geographers. It is a curious fact that all the great nautical discoveries of the world were achieved before the power of steam had rendered the sailor independent of wind and tide: but with the peculiar aid of rapid locomotion the mind of man is not content with ancient beaten paths, but seeks to lessen the distance of remote countries by adopting new and direct means of communication. It appears to many of us as the affair of yesterday that the overland route to India was established by the indefatigable Waghorn (whose name should ever be held in honour); but in the short space of about fifteen years the camel has ceased to be the "ship of the desert" upon the Isthmus of Suez: a railroad connects the Red Sea with the Mediterranean, a canal already conveys the sweet waters of the Nile through deserts of arid sand to Suez, and a fleet of superb transports upon the Red Sea conveys our troops direct to India. Who can predict the future? who can declare the great French work to be impossible, and deny that within the next half-century the fleets of the Mediterranean will sail through the Isthmus of Suez upon the Lesseps Canal?

England has been the first to direct to general use the power of steam. Our vessels were the first to cross the Atlantic, and to round the stormy Cape to India. The name of Stephenson will live for ever as the inventor of the railway, and that of Wheatstone as the adaptor of electricity to the telegraph; but, proud as we may be of these great inventions which by the reduction of space bring distant countries into close communication and tend to civilization, have we not thus destroyed the spell that kept our shores inviolate? Not only ourselves, but the French also possess a magnificent line of transports upon the Red Sea. We can no longer match the dexterity of our sailors against overwhelming odds. Steam breaks the charm! Wars are the affair of weeks or days; there are no longer the slow marches that rendered inaccessible far-distant points; the railway alters the former conditions of all countries.

Without yielding to exaggerated alarm, we must watch with intense attention the advances of Russia upon the Indian frontier; and beyond all geographical enterprises we should devote extreme interest to a new and direct route to India by the Euphrates Valley and the Persian Gulf, thus to be independent of complications that might arise with Egypt. . . . . . Thanks to the devotion and zeal of the distinguished President, Sir Roderick Murchison, the Royal Geographical Society has of late years received so great an impulse that it comprises at this moment 2130 Members; there is no exploration of any importance that can be undertaken throughout the world without the knowledge and the attention of this Society. Thus not only are we forewarned of the encroachments of neighbouring powers, should their expeditions be pushed beyond the limits of necessity, but we form a nucleus for all geographical information, should the Government resort to us in an emergency.

Free from all jealousy and above suspicion, we have this year awarded to the Russian Admiral, Boutakoff, the Founder's Gold Medal, for having been the first to launch a steamer on the Sea of Aral, and to conduct his vessel upwards of 1000 miles along the course of the river Jaxartes.

The Victoria Gold Medal has been conferred upon that eminent Arctic voyager, Dr. Isaac Hayes, who by reaching the highest northern latitude hitherto attained (81° 35′), in his arduous voyage towards the open Polar Sea, has nobly sustained the honour of America. Thus the year 1867 affords an interesting proof of the unprejudiced patronage of the Society, as both the Founder's and the Patron's Medals have been bestowed upon these distinguished foreigners.

It is not my intention to enter into the details of the geographical explorations of the past year, that have been so ably enlarged upon by Sir Roderick Murchison in the exhaustive review contained in his annual address of May 27th; but it is my duty to bring to your notice those most important geographical facts which, from their recent occurrence, claim our present attention. In Africa, we have to record the noble expedition of Mr. Gerhard Rohlf, who has safely returned from his remarkable journey across the Sahara from Tripoli, *via* Ghadames and Murzuk, to Kuka, on the shores of Lake Tchad; thence south to Benué, down that stream to its junction with the Niger, and then across by land to Lagos in the Bight of Benin. In Abyssinia we are about to commence a military expedition, to which we trust Her Majesty's Government will attach a staff of men of science that may return

with valuable results. The importance of explorations was never more forcibly exemplified than in the present instance, when a war is about to commence in a wild country of which the military authorities are utterly ignorant, and solely dependent upon the accounts of private travellers. In Asia, we have to remark upon the extraordinary progress by the Russians in geographical enterprize, who by their settlements in Manchuria and explorations of the Khinka Lake, and the navigable rivers Usuri and Amoor, are laying the foundations for the future development of that hitherto neglected portion of the world. When we regard the vigorous steps that have been adopted by Russia in Northern Asia, we turn with increased attention to the energetic appeal of General Sir Arthur Cotton for an exploration of that unknown land between the Burhampooter and the Yang-tze, with a view to open a free communication between India, with its 200 millions, and China, with its 400 millions of inhabitants. In America we devote increased attention to inter-oceanic communication across the Isthmus, upon which interesting subject papers will be read before this Association by Lieutenant Oliver, on a recent exploration of a new route across Nicaragua, under the direction of that well-known and energetic explorer, Captain Bedford Pim.

No striking geographical feat has been performed by England during the present year; but the anxiety not only of geographers but of Englishmen of all classes is painfully keen upon a subject of universal interest—the reported death of Dr. Livingstone. It is well known that this eminent traveller was engaged in an important exploration, with the intention of determining the watershed of Eastern equatorial Africa. His object was to prove by actual inspection whether the Nyassa, from which the Shiré flows to the Zambesi, was fed by a river from the north; he was then to reach the Tanganika Lake of Burton and Speke, and prove whether a river issued from that lake towards the south, or whether some river fed that lake from the south; he was then to navigate the Tanganika to its northern extremity, and prove whether it was fed by a river from the north, or whether it communicated with the Albert N'yanza. With this great journey before him, Dr. Livingstone had reached and crossed over the northern portion of the Nyassa, which appears to have been so shallow that the canoes were poled across a sandy bed; this would suggest the existence of some tributary of the northern extremity of the lake that in annual floods had brought down the deposit.

Upon arrival on the western shore, he found himself in the hostile country of the Mazite, and during the march, a few days later, the party was suddenly attacked and overpowered.

By the report of nine Johanna men and their leader, Moosa, who, after great difficulties, returned to Zanzibar, it appears that Livingstone killed two of his assailants, but was himself struck down by the blow of an axe on the back of the neck. Moosa and the Johanna men had concealed themselves in a thicket, but after dark they ventured to the scene of the recent conflict, and discovered the body of Livingstone with those of several of their own party and two of the enemy. They scraped a hole in the earth and buried the body of our lamented traveller.

This happened in about August 1866; we have therefore been twelve months without further tidings. There are some persons (among others, my highly honoured and much-loved friend Sir Roderick Murchison) who still cling to the hope that Livingstone is alive, and that the story of the Johanna men is false, and merely a lame excuse for the desertion of their master.

The fate of Livingstone, our common friend, of whom we are all justly proud, is so intensely interesting, that I may be excused for expressing my gloomy opinion: I believe him to be dead.

Those who still hope, cling to the fact that the Johanna men are renowned as liars, and that they have trumped up a story to excuse their return. It is this very fact of their power of consummate lying that convinces me of the substantial truth of their statement. Natives are scientific liars; they do not lie absurdly, like Europeans, but they concoct their falsehoods with such forethought, that the lie itself is an example of profound skill. No native, that I have ever seen, would commit himself to so inartistic a lie as to declare to be dead a man who is still alive, who would become a witness at a future time against him. Should natives intend to desert

their master, they invariably plead excuses that cannot be proved to be false, such as sickness, or pretended lameness, that incapacitates them from marching; but the hardihood of the Johanna men in committing themselves, by the confession of their cowardice, is a surprising instance of veracity that could only have been prompted by the urgency of the calamity. To confess the death of the master is the extreme of moral courage, as a native would dread the suspicion that might fall upon him as the murderer; therefore the story of poor Livingstone's murder, although differing in details, as described to various people by Moosa, I thoroughly believe to be substantially correct; and this belief, I regret to say, is shared by Dr. Kirk, our Vice-Consul at Zanzibar, who was Livingstone's former companion on the expedition to the Nyassa.

With this sad conviction that Livingstone has passed away for ever, and that his bones now lie beneath that fatal soil of Africa that has been his glorious stage, I can only, as a fellow traveller in the rough path of African research, exclaim:—"Peace to his memory! honour to those remains that moulder in the dust, a sacrifice to philanthropy in that distant and hopeless field, where the hand of friendship is spurned, and where a murderous stab is the reward for Christian enterprise!" There is no stone to mark the spot where the great traveller lies; but as a gallant sailor's corpse is given to the waves, and rests in death within the element with which in life he struggled, so rests the body of our tired pilgrim, covered with the soil of Africa, as with a flag that enfolded him in victory. His name will never die, but, deeply graven on the hearts of all mankind, it will descend in history.

And now, before I close this address, I must refer with pride and satisfaction to the vigour and alacrity that has been exhibited, not only by the Royal Geographical Society, at the earnest instance of our sterling President, Sir Roderick Murchison, but also by Her Majesty's Government, in despatching, without a moment's unnecessary delay, an expedition to Eastern Africa to investigate the fate of Livingstone. Should he be no more, the arrival of an armed expedition in his search will be a lesson to the savage tribes that no Englishman can disappear without an inquiry into the cause; and good service will be done to geography by the party under Mr. Young, who, provided with a steel boat, will be able to decide whether the Nyassa is fed by a river from the north.

The most interesting African problem yet remains to be solved. Within the last few years we have determined the great reservoirs of the Nile, and we have proved that the river, hitherto so mysterious, is the offspring of two great causes—the vast equatorial reservoirs the Victoria and Albert Lakes, and the sudden rains of Abyssinia that in July, August, and September cause the inundation in Lower Egypt: that portion of the question I shall shortly publish as the 'Nile Tributaries of Abyssinia.' But although the mystery of ages is solved, much remains to be explored. We know but a portion of those immense reservoirs; and geographers will not remain content with the bare fact that the Nile issues from those lakes; but England, that has untied the knot, must gather in the extremity of the line. The death of Livingstone is a fearful drag upon the wheel of African exploration. There are many as brave, many as adventurous; but there are few who combine the qualifications of patience and endurance that are so sorely needed in that most difficult of all thorny paths, "African research." Still we must not despair: we have of late years acquired an ally that is the grand supporter of geographical exploration, a supporter that assists us through paths that were closed before the providential aid appeared; and in those swamps whose fatal malaria slew with infernal certainty the brave and daring explorers of former times, *quinine* is the guard and faithful escort of the traveller. Armed with this cuirass, we can penetrate through countries hitherto impassable. The advancement of science has so far practically augmented the power to civilize, that, with drugs hitherto unknown, conveniences that preserve the traveller from the vicissitudes of climate, such as waterproofs &c. &c., fire-arms of deadly precision, astronomical instruments, steel and india-rubber boats of infinite variety, not only can we push through obstacles that were formerly insurmountable, but we can return with scientific results, and leave behind us in those savage countries a path and introduction for future travellers.

But even when these facilities are absent, there is one great quality that, if life remains, may overcome all difficulties, a quality for which, I trust, Great Britain will ever be renowned—"*determination.*" When we met Speke and Grant (the Englishman and the Scotchman) at Gondokoro, they had nothing except guns, ammunition, beds, and quinine; and still they had overcome all difficulties. When my wife and I returned two years later to the same spot, we had had no quinine for eighteen months, our steel boat had been our large *sponging-bath*, our india-rubber floats had been *inflated goatskins*; and nevertheless we are here now, thanks to the guidance of a Divine Providence!

But, next to Providence, there is a support to which an English traveller clings when far, far away from civilization, in countries unknown and trackless. He may be in misery and helpless, he may have lost all hope of return, and sickness may have stricken him to the margin of his grave; but as his last thoughts wander towards all those left behind, and he weighs the fatal end against the results of his mission, of one thing he feels certain:—His Government may ignore him, friends may forget him, but the Royal Geographical Society, with Murchison at the head, will never forsake him; if dead, he will be sought for; and should he return alive, their approbation of his labours will be his great reward.

Confident in this support, the hardy pioneers of Great Britain will flock to the thinned ranks of the explorers. Speke lies buried in his native village-church; Livingstone, we fear, lies far away; but the monument we raise to these brave men will be the starting-point for others, who may equal their great deeds. And should the traveller fall in the noble task, and die in a lonely and distant land, if no friendly voice be near to bid farewell, he still will have a consolation: in the last hour, a spirit will whisper these words of comfort to his soul, "England expects that every man will do his duty!"

Notes of a Reconnaissance of some Portions of Palestine made in 1865–66 *for the Palestine Exploration Fund.* *By* Lieut. Anderson, *R.E.*

The reconnaissance survey commenced at Baneas, near the source of the most important tributary of the Jordan. The latitude was carefully fixed, the position of the junction of the Jordan and Baneas streams determined, and the places connected by compass-bearings. A base was thus obtained on which to frame the triangulation to the mountains on both sides of the valley. From Baneas an azimuth line was observed to a prominent peak about ten miles distant on the west side of the valley, and the latitude of the survey camp at the village of Hunin, near the peak, determined. From Hunin the watershed was followed, which for topographical reconnaissance afforded great facilities, as a clear view was always obtained to great distances east and west, and all important places visible within eight or ten miles were fixed by triangulation. The next camp was fixed at Kedes, and connected with that of Hunin by an azimuth line. The survey then removed to the village of Alma, overlooking the lake of Huleh, eighteen miles distant from Baneas, and the line of azimuths connected hence with the watershed of Kefr Birim. Explorations were made to the north, twelve or fifteen miles, and all mountain-tops and villages within access visited and surveyed. To the south of Kefr Birim the culminating highlands of Upper Galilee, which had never been previously examined, were thoroughly explored. From Jebel Jurmuk, about 4000 feet above the sea-level, Cape Carmel could be distinctly seen. The next camp was pitched at Safed. Safed Castle has a most extensive view in every direction, except north-east, where a hill 200 feet higher intervenes. A triangulation and survey of the whole of the Sea of Galilee and adjoining mountains was next made. The reconnaissance was extended about eight miles to the westward to the village of Ailaboon, and proceeding southward, embraced the country over which the Crusaders made their disastrous march from Sepphoris to Kurn Hattin. From Nazareth Wely a view was obtained over the beautiful plain of Esdraelon, and observations made to many points, including others to Mount Ebal, thirty-five miles further south. As far south as Jeuin the watershed was explored and mapped out to the bend of the Leontes, about sixty miles distant in a straight line. The watershed to the eastward of Nablus had not yet been explored by any traveller.

The survey of the watershed was commenced again a little north of Mount Ebal, and explored continuously as far as Jerusalem, which is situated itself on the main watershed of the country. The reconnaissance was extended through the Bedouin country to the Jordan, and the much-disputed position of Jisr Damieh connected with the sites previously fixed. The country to the eastward of Nablus was visited and mapped; Jebel Azur, Mount Gerizim, Mount Ebal, and Kurn Turtabeh were also connected with the survey; and it was finally protracted to Jaffa, thus establishing a connexion between this place and Baneas.

On the Lagoons of Corsica. *By* Prof. D. T. Ansted, *F.R.S.*

The eastern coast of Corsica is the most malarious district in the Mediterranean; but this has only been the case within the historic period. 2000 years ago there was a defensible town on the coast called Aleria, and 120 years later a Roman colony was established there, the seat of a large trade. This continued and the coast was inhabited till the Middle Ages, when the pirates of the Mediterranean forced the inhabitants back into the hills. In the early part of the sixteenth century the plains ceased to be habitable, and they have never since been without deadly malaria in the summer. Mariana, another ancient and mediæval colony near the lagoon of Biguglia, had also been deserted. To the north of the sites of both these ancient towns extends a lagoon, formerly, in all probability, an open bay. The fine sand and mud of the rivers and watercourses are carried towards the north, and form a bar or wall of sand in advance of the coast. Behind this bar, wherever there are torrents between the rivers, a pool or lagoon is formed—these torrents not being able to keep open a channel to the sea. But a communication must be kept up, partly to enable the surplus waters to escape to the ocean during winter, and partly to admit the sea to the pool when, during summer, the contents are evaporated. Meanwhile all the organic matter brought down by the torrents is retained in the lagoon, decomposes there, and is converted into miasmatic vapour. So long as there is free communication to the sea there is no malaria; but when the lagoon is formed malaria sets in. The lagoon of Biguglia extends 8 miles towards the north; its greatest width is about $1\frac{1}{2}$ mile. The wall or bank separating the lagoon from the sea is from 900 to 400 yards wide, and its height is about 9 feet above the level of the Mediterranean. There are two cuts, which are now filled up. The deepest part of the lagoon is 10 feet, and much of it is not more than 3 feet. The water is nearly fresh in winter, and everywhere brackish in summer. The lagoon receives the drainage of 45,000 acres, and contains itself 4800 acres. The quantity of rain averages 24 inches per annum, of which 6 inches fall in November and 4 inches in October. More than 2 inches has fallen in 24 hours, nearly 4 inches in a week, and about 12 inches in 4 weeks. From a consideration of these measurements, it is evident that the lagoon might rise 6 inches in 24 hours, and as much as 3 feet in a month, if it were not for the outlet to the sea: a channel will thus always be kept open. 2000 years ago the mud and sand of the Golo had not formed a bar in front of the bay, the shore of which was within the inner shore of the lagoon. There was no effectual barrier preventing the waters of the torrents reaching the sea until three centuries ago. Thus within 1700 years there has been commenced and completed a bank of sand 7 miles in length, a quarter of a mile wide, and about 15 feet high—the result of two rivers, the Golo and the Bevinco. The deposit is equivalent to about 75 grains of solid matter deposited on an average by each gallon of water. There is no evidence of any elevation of land within the recent or historic period that can explain the change that has taken place. It is evident that the lagoon has been formed by the accumulated sands and mud, and that the malaria is due to the closing of the lagoon. It is in the highest degree desirable that these lagoons should be got rid of or rendered innocuous. This can be done, in the lagoon of Biguglia, by separating the area into two unequal parts. The larger area might be drained by pumping, at a moderate cost, and kept dry by the same machinery occasionally used; part of the smaller area might be converted into the channel of the Bevinco, and the rest drained by inexpensive machinery. The redeemed lands would be of great value; but the principal result would be felt in the im-

provement of the sanitary state of the adjoining districts. The experience of Mr. Bateman in Minorca seems to prove that malaria may be removed by the drainage of lagoons, and the surrounding population raised thereby from their present state of apathy and stagnation.

On Walvisch Bay and the Ports of South-West Africa. *By* THOMAS BAINES, *F.R.G.S.*

The importance of Walvisch Bay is due to its being the best harbour on this part of the African coast, and to the existence of mines of copper in the neighbouring interior. It lies in lat. 22° 27′ S., and comprises the estuary of the Kiusip river, where there is well-sheltered anchorage for vessels of almost any size. So arid and sandy is the climate, that the river contains water only during a few weeks of the rainy season, and fresh water for consumption is obtained by rolling casks from Sand Fountain, four miles distant. The country in the vicinity is peopled by Namaqua Hottentots and Damaras. The value of British imports one year amounted to £250,000, and the author advocated the establishment of a commissioner in the port, authorized to hoist the British flag, regulate the commerce of the place, and settle questions that arise between the traders and the natives. The country abounds with cattle, which might become objects of a large export trade. The copper found is a rich heavy ore, greenish or dark purple; but sometimes bolts of pure native copper are met with. 628½ tons of copper were shipped during the month of May 1867.

Exploration of Beloochistan and Western Scinde, with a view to examining the Subterranean Supply of Water. *By* J. W. BARNES.

The author commenced his operations at a place about eight miles north-east of Kurrachee, where, after some weeks' labour, he succeeded in piercing the first water-bearing strata, when the water rushed up and overflowed the surface, continuing, without intermission, to the present time. Water was obtained at other places in the arid country, and springs were visited which are from 60 to 300 feet above the valleys. With this evidence of subterranean water, we are bound to inquire where is the source. Originally, of course, it is derived from rain or snow. The desert country of Scinde is often spoken of as destitute of rain. The rainfall averages, indeed, only 4 inches per annum; but if we glance at a map of Asia, we observe, between the eastern borders of Persia and the western boundary of the Scinde and Punjab valleys, a tract of country 330,000 square miles in extent, with a mountainous and humid area, from 3000 to 12,000 feet above the sea-level, from which a considerable subterraneous supply of water must be derived. Granting an average annual rainfall of 3·75 inches over this area, and as we know that in every country a portion of the rainfall, estimated from one-third to one-twelfth, percolates and is absorbed by the permeable strata, there is room for a strong inference that a vast body of water is available over the whole of the region, between the thirtieth parallel of latitude and the Indian Ocean. It is recorded by navigators that large springs of fresh water burst up through the sea in the neighbourhood of Cape Ormuz. The formation of this part is, undoubtedly, tertiary; and the stratification of the hills, where not horizontal, generally inclines either to the eastward or southward.

A Boat-journey across the North end of Formosa from Tam-suy to Kelung. *By* DR. COLLINGWOOD, *M.A., F.L.S.*

This paper gave an account of the towns of Hoo-wei (or Tam-suy) on the north-west coast of Formosa, and a treaty-port; of Bangka, an interior town, the capital of that part of the island; and of Kelung, another treaty-port, upon the north-east coast. The journey was made by way of the Tam-suy river, passing the towns of Kan-tow, Pah-chie-nah, Sik-kow, Chuy-teng-cha, to Kelung; and the author described the chief features of the fauna and flora noticed on the way. He also entered particularly into the characteristics of the native population, their occupation, characters, and general economy.

On the Coasts of Vancouver's Island, British Columbia, and Russian America. *By* P. N. Compton.

The author described the physical outlines of the coast-region of these countries, visited by him during eight years' service in the Hudson's Bay Company, at Vancouver's Island. The most marked feature, between the straits of De Fuca and the fifty-ninth parallel of latitude, is the numerous long inlets in the rocky precipitous coasts. They run generally in a north-easterly direction, and vary in length from thirty to seventy miles. The scenery in most of these inlets is grand in the extreme: every few miles cascades of water leap down the lofty, rocky sides, proceeding from the melting snows of the peaks that tower up a short distance in the interior. An enumeration of these inlets was given, together with a more detailed description of several of them. It is a curious feature that none of the large rivers of these countries discharge themselves into these deep inlets. Lynn's canal, in Russian America, has large glaciers in its valleys, extending to the sea-shore, from which they are separated sometimes only by a belt of trees. The climate here is very severe; and the author has seen, in the month of May, 4 feet of snow close to the sea-level. This inlet is one of the longest on the coast, extending inland about seventy miles; but it averages only about two miles in width. The climate of Russian America is extremely severe; it is doubtful if any crop but potatoes could be raised on its poor soil, and the amount of available land is very limited.

On the Antiquity of Man. *By* John Crawfurd, *F.R.S.*

Considerations were adduced by the author of this paper in support of the view hat the period embraced by architectural and other records of the most ancient nations forms but a small portion of the time that has elapsed since man's first appearance on the earth. From the time in which he acquired the skill to frame such records, we have to trace him back, over the many stages he had to pass through, up to the discovery of his remains in caves, and even of those of his handiwork in the most recent geological formation, the "drift." The localities, moreover, which were favourable to the development of a people sufficiently advanced to produce enduring records of their existence are few in number. To trace man's existence up to its earliest date, according to the author's view, we must go beyond this, to the time when he was without speech, ignorant of every art, and, like the lower animals, chiefly guided by instinct.

On the History and Migration of Sacchiferous or Sugar-yielding plants in reference to Ethnology. *By* John Crawfurd, *F.R.S.*

On the Animal and Vegetable Food of the Aborigines of Australia. *By* John Crawfurd, *F.R.S.*

On the supposed Plurality of the Races of Man. *By* John Crawfurd, *F.R.S.*

On the supposed Aborigines of India, as distinguished from its Civilized Inhabitants. *By* John Crawfurd, *F.R.S.*

On the Complexion, Hair, and Eyes as Tests of the Races of Man. *By* John Crawfurd, *F.R.S.*

On the Dissemination of the Arabian Race and Language. *By* John Crawfurd, *F.R.S.*

Arabia, from one extremity to another, is inhabited by a single race of man, apparently its aborigines. The physical geography of their country must have early divided the Arabs into two usually distinct classes—the nomadic shepherds for the desert, and the fixed agriculturists for the less sterile part of the country. Had the people of Arabia been African negroes, or Malays, or even Hindoos, we may safely

believe that in their inhospitable land they would never have attained even the modest measure of advancement they have exhibited, but, on the contrary, would have remained in the savage condition of some Africans, or Red Indians, whose condition was far more auspicious. But the Arab is of higher intellectual quality than any other race of Asia, in many respects not being surpassed even by the Chinese; and this superiority is evinced by the predominance they exercise when they come into contact with any of the other races of Asia. At some very remote and unknown time, a settlement of Arabs took place in the neighbouring country of Syria, the evidence of whch is the existence in Hebrew of many Arabic words. With this obscure exception, the long isolation of the Arabs continued down to the time of Mohammed. Under the inspiration of the religion of their prophet, they left their own country, and at once commenced a career of conquest which, for rapidity, durability, and extent has no parallel. Transplanted to better lands than their own, the Arabs appear to have improved or fallen off, chiefly in proportion to the quality of the race with which they commingled. They became deteriorated amongst the Syrians and Egyptians, and their greatest social advancement was, probably, when they came into contact with a European people in the Spanish peninsula. It was in foreign countries only that they made advance in civilization. Their literature and their architecture all sprang up in foreign countries. They were not themselves discoverers or inventors, and the benefit they conferred on mankind consisted only in their being the agents through which the discoveries and improvements of other nations were widely disseminated. It was, for example, through their active mediation that the arts of distillation and paper-making (Chinese inventions) reached Europe; and the western world owes to them the introduction of many useful plants, as rice, cotton, the sugar-cane, the opium-poppy, the orange, and the melon. The number of Arabic words introduced into foreign languages varies with the influence exercised by the religion of the Arabs, and the capacity of the people to comprehend it. The language has nowhere but in Syria, Egypt, and Barbary made any approach to the supercession of the native idioms of countries conquered by the Arabs. The great disparity which existed between the manners, habits, and pronunciation of a European and an Asiatic people made the number of Arabic words introduced into the Spanish language comparatively inconsiderable, and their corruption great, although the power of the Arabs in the Spanish peninsula endured, from first to last, 778 years.

Life amongst the Veys. *By* H. C. Criswick.

On the Character of the Negro, chiefly in relation to Industrial Habits. *By* Dr. John Davy, *F.R.S.*

In this paper the chief object of its author was the vindication of the Negro, who, he believes, has been unjustly considered a sluggard and inveterately idle.

The argument used is of two kinds; one is founded on the organization of the African, excellently fitted for work, indeed the very cause, under a mistaken humanity, of his first importation into the West Indies, with the vain hope of preserving the feebler and cruelly worked natives.

The other (resting on experience), a very extensive experience, proving that with equal motives to be industrious, the negro is not inferior to the white man in industry.

The author adduces instances of conduct on the part of negro labourers that would be highly creditable to Europeans in the same condition of life.

He concludes with the expression of belief that such peculiarities as belong to the negro, as colour of skin, quality of hair, &c., are of a kind suitable to him in his native climate, and beneficial under a tropical sun and in a malarious atmosphere, and not of a nature to allow of his being considered either as a distinct or inferior variety of the great human family. And further, that he is as capable as the white man, under continued education, in favourable circumstances, and freed from the curse of slavery, of becoming civilized, and of making progress in the liberal arts and sciences. One fact is dwelt on as of a very promising kind, viz. that those tribes in the far interior, mountainous regions of Africa,

where slavery has least prevailed, and where the climate and soil are good, are most advanced, probably as much so in civilization and the useful arts, such as the working of iron &c., as were the ancient Britons about the time of the first Roman invasion.

On Exploration in Palestine. By CYRIL GRAHAM, *F.R.G.S.*

An Association was formed two years ago for the purpose of exhaustively exploring the Holy Land. The first announcement of its object was met by surprise, that such a work had still to be executed. Had not the scores of travellers, it was asked, who annually traverse Palestine, brought all the information that could be desired? But ninety-nine out of every hundred of these rigidly follow the same track, and hurry home without adding an atom to our knowledge.

What is proposed, in the first place, is a trigonometrical survey on a large scale, in which every village and every mound which marks the site of what once was a village, every glen, every scar, every spring, every feature, be it ever so small, of presumptive importance shall be delineated.

Then we wish to know the materials of which old Hermon and the Lebanon are composed; the fossil remains of ancient creatures imbedded in their sides; the nature of the soils; all the trees of the mountains; all the flowers of the plains which cover the land as a carpet in the spring of the year; all the fishes of the Sea of Tiberias; all the phenomena of that most remarkable of basins the Dead Sea. We want, too, a catalogue of the beasts and reptiles, in which the crocodile will appear, —of the birds, of the butterflies, of the beetles, and the smaller entities of creation, in all their varieties. In short, we want that book rewritten, which has not been transmitted to this day, composed by a master of science 3000 years ago, which treated of plants, from the hyssop that is on the housetop to the cedar that is upon Lebanon, and of the birds, and the beasts, and the creeping things, and the fishes of that land.

Again, if we turn towards the East, to the other side of Jordan, there is seen a spacious field for future labour,—Moab, barren and wild; Gilead, with its forests, and Bashan, with its cities walled and unwalled, from which the Children of Israel, by divine help, expelled the Rephaim. Edrei and Salcah were the limits of Og's kingdom. Edrei, entrenched in a labyrinth of rocks, is a stronghold which would still task the unaided arm of man to conquer; the castle of Salcah on the southernmost spur of the hills of Bashan commands to this day the approach to the old kingdom from the east, and the descendants of the Oaks, which excited the admiration of the sacred writers, have never ceased to cling to the range which their ancestors adorned.

In the heart of Bashan lies Argob, that curiosity of geology, a mass of once molten matter, tossed and torn and twisted and upheaved, resembling more nearly the appearance of the moon, as revealed to us by Lord Rosse's telescope, than a condition of things on the earth.

Beyond the mountains which form the barrier of Bashan, a duplicate occurs of this work of the convulsion of nature, and groups of towns, scattered over the plain, these many ages desert and desolate, remain as monuments of the proficiency in more than one art of a very early period.

The author in conclusion said, "I feel that this great congress, which has met to consider the modes in which human research may be best conducted, will hardly require of me an apology for introducing to it, and begging for it the right hand of fellowship, an Association which proposes to confer, and which, if the means be granted, will confer such a benefit on so many branches of knowledge.

"We have no section for archæology, no section for history, no section for theology, but these sciences will likewise profit, and above all—and this is the primary object that we have in view—a light will be thrown upon the birthplace of our faith, upon the configuration and the products of the country, and the way of living of a people far different from ourselves, enabling us to read with a more vivid interest, and a more real intelligence, the scenes so graphically depicted in the Scriptures."

On some Changes of Surface affecting Ancient Ethnography.* *By* H. H. Howorth.

In this paper the author claimed to prove that the accounts given by Pliny and the other Roman geographers, of the physical conformation of Scandinavia, namely, that it was then an archipelago of large islands, has been abundantly sustained by the evidence collected by Swedish observers since the seventeenth century, by the minute inspection made in 1833 by Sir Charles Lyell, and by subsequent investigations, which evidence is to the effect that the whole of the land north and north-east of Stockholm is rising rapidly, and that the Baltic is becoming more limited in area every day. This area of elevation has been extended by many observers into Central Asia, where the Caspian within the historic period has receded enormously, the former conjunction with it of the sea of Aral being only a very limited index of this depletion. From these facts the author deduced the conclusions,—

First, that the rhetorical expression of "the northern hive" is more than ever an exaggeration, and that we must look elsewhere for the cradle of the great majority of invading peoples who overturned the Roman empire.

Secondly, that the filling up of a large area in Southern and Central Asia with sea and marsh in ancient times must affect the positions of its races as given in orthodox geographies, and offers a suggestive field for those who, like himself, are interested in the causes of the continuity and the idiosyncracies of the Indo-European family.

On the Origines of the Norsemen. *By* H. H. Howorth †.

The author held the view of Hallam and others to be untenable, namely, that the sudden eruption of Norsemen into western Europe, and their ferocity, were due to the Saxon wars of Charlemagne, which sent many of the chiefs of that race beyond the limits of Germany, and in revenge of which they afterwards returned to be the scourge of all Europe. The only explanation of the many peculiarities of the Norsemen is to be found in the fact of their having been but late immigrants into the area whence they emerged so powerfully and so suddenly. Their own traditions, their epics and war-songs contain no allusions to such a tempting and suggestive subject as the wars of Charlemagne. After passing in review all that could be found in classical writers bearing on the subject, the author believed that the balance of evidence was in favour of identifying the Norsemen with the Roxelani, literally "red-haired men," and that these were the same as the Sarmati, who have been erroneously considered to be a Sclavonic nation.

The Ethnography of the French Exhibition, as represented by National Arts. *By* Mrs. Lynn Linton.

The author considered that, apart from all question of commercial value or social gain, the Exhibition had at least one feature of undoubted importance, namely, its ethnological material, which is singularly rich both in amount and suggestiveness. Every variety of art is to be seen, from the rude works of the savage, whose finest ideas are embodied in a necklace of shells, a mask of tattoo, or a temple of skulls, through the intermediate grades of the semicivilized making their first efforts, up to the latest productions of European skill. The archæological gallery of the Exhibition leads us by successive stages from the primitive conditions of the lake-dwellers to the complex life of modern times. The work of each nation, even in the department of jewellery, has a distinctive character of its own, evidencing the peculiar habit of thought and intellectual status of the race. The European, with all his science, cannot come near the exquisite grace of the unlearned Hindú or the wandering Kurd. There is a strongly marked dissimilarity of intention in Eastern and Western work. There is no national life, no public meaning in anything that comes from the East. It is all small and indi-

* This paper will be printed at length in the Transactions of the Ethnological Society for 1868.

† This paper is printed at length in the Transactions of the Ethnological Society for 1867.

vidual work, for a few grand men and their harems; nothing for the mass of the people. The West, on the contrary, shows its mechanical improvements and grand scientific discoveries, planned to lessen the toil of labour and multiply its products, so that the poor shall profit as well as the rich. We learn the truth of this view in a very small and quite unimportant matter, valuable only as an indication. Both West and East send models of their fruits, costumes, trades, &c.; but the East sends them as toys—mere playthings, which are made to amuse and not to instruct; while the models of the West are in aid of horticultural or ethnographical science, the final cause of which is public good, not private pleasure.

On the Origin of Civilization and the Early Condition of Man. *By* Sir JOHN LUBBOCK, *Bart., F.R.S., Pres. Ent. Soc. &c.*

Side by side with the different opinions whether man constitutes one or many species, there are two opposite views as to the primitive condition of the first men, or first beings worthy to be so called. Many writers have considered that man was at first a mere savage, and that our history has on the whole been a steady progress towards civilization, though at times, and sometimes for centuries, some races have been stationary, or even have retrograded. Other authors of no less eminence have taken a diametrically opposite view. According to them, man was from the commencement pretty much what he is at present. If possible, even more ignorant of the arts and sciences than now, but with mental qualities not inferior to our own. Savages they consider to be the degenerate descendants of far superior ancestors. Of the recent supporters of this theory, the late Archbishop of Dublin was amongst the most eminent. In the present memoir I propose briefly to examine the reasons which led Dr. Whately to this conclusion, and still more briefly to notice some of the facts which seem to me to render it untenable. Dr. Whately enunciates his opinions in the following words:—"That we have no reason to believe that any community ever did, or ever can emerge, unassisted by external helps, from a state of utter barbarism, into anything that can be called civilization. . . . . Man has not emerged from the savage state; the progress of any community in civilization, by its own internal means, must always have begun from a condition removed from that of complete barbarism, out of which it does not appear that men ever did or can raise themselves." One might at first feel disposed to answer that fifty cases could be cited which altogether discredit this assertion; and without going beyond the limits of our own island, we might regard the history of England itself as a sufficient answer to such a statement. Archbishop Whately, however, was far too skilful a debater not to have foreseen such an argument. "The ancient Germans," he says, "who cultivated corn, though their agriculture was probably in a very rude state, who not only had numerous herds of cattle, but employed the labour of brutes, and even made use of cavalry in their wars, . . . these cannot with propriety be reckoned savages, or if they are to be so called (for it is not worth while to dispute about a word), then I would admit that in this sense man may advance, and in fact have advanced, by their own unassisted efforts, from the savage to the civilized state." This limitation of the term "savage" to the very lowest representatives of the human race no doubt rendered Dr. Whately's theory more tenable by increasing the difficulty of bringing forward conclusive evidence against it. The Archbishop, indeed, expresses himself throughout his argument as if it would be easy to produce the required evidence in opposition to his theory, supposing that any race of savages ever had raised themselves to a state of civilization. The manner in which he has treated the case of the Mandans, a tribe of North American Indians, however, effectually disposes of this hypothesis. This unfortunate tribe is described as having been decidedly more civilized than those by which they were surrounded. Having, then, no neighbours more advanced than themselves, they were quoted as furnishing an instance of savages who had civilized themselves without external aid. In answer to this, Archbishop Whately asks—"First, How do we know that these Mandans were of the same race as their neighbours? Secondly, How do we know that theirs is not the original level from which the other tribes have fallen? Thirdly and lastly, supposing that the Mandans did

emerge from the savage state, how do we know that this may not have been through the aid of some strangers coming among them—like the Manco-Capac of Peru—from some more civilized country, perhaps long before the days of Columbus?" Supposing, however, for a moment, and for the sake of argument, that the Mandans, or any other race, were originally savages and had civilized themselves, it would still be manifestly, from the very nature of the case, impossible to bring forward the kind of evidence demanded by Dr. Whately. No doubt he "may confidently affirm that we find no one recorded instance of a tribe of savages, properly so styled, rising into a civilized state without instruction and assistance from people already civilized." Starting with the proviso that savages, properly so styled, are ignorant of letters, and laying it down as a condition that no civilized example should be placed before them, the existence of any such record is an impossibility; its very existence would destroy its value. In another passage Archbishop Whately says, indeed, "If man generally, or some particular race, be capable of self-civilization, in either case it may be expected that some record, or tradition, or monument, of the actual occurrence of such an event should be found." So far from this, the existence of any such record would, according to the very hypothesis itself, be impossible. Traditions are shortlived and untrustworthy. A "monument" which could prove the actual occurrence of a race capable of self-civilization, I confess myself unable to imagine. What kind of a monument would the Archbishop accept as proving that the people which made it had been originally savage? that they had raised themselves, and had never been influenced by strangers of a superior race? Evidently the word "monument" in the above passage was used only to round off the sentence. But, says Archbishop Whately, "We have accounts of various savage tribes, in different parts of the globe, who have been visited from time to time at considerable intervals, but have had no settled intercourse with civilized people, and who appear to continue, as far as can be ascertained, in the same uncultivated condition;" and he adduces one case, that of the New Zealanders, who "seem to have been in quite as advanced a state when Tasman discovered the country in 1642, as they were when Cook visited it 127 years after." We have been accustomed to see around us an improvement so rapid that we forget how short a period a century is in the history of the human race. Even taking the ordinary chronology, it is evident that if in 6000 years a given race has only progressed from a state of utter savagery to the condition of the Australian, we could not expect to find much change in one more century. Many a fishing village, even on our own coast, is in very nearly the same condition as it was 127 years ago. Moreover, I might fairly answer that according to Whately's own definition of a savage state the New Zealanders would certainly be excluded. They cultivated the ground, they had domestic animals, they constructed elaborate fortifications, and made excellent canoes, and were certainly not in a state of utter barbarism. Or I might argue that a short visit, like that of Tasman, could give little insight into the true condition of a people. I am, however, the less disposed to question the statement made by Archbishop Whately, because the fact that many races are now practically stationary is in reality an argument against the theory of degradation and not against that of progress. Civilized races, say we, are the descendants of races which have risen from a state of barbarism. On the contrary, argue our opponents, savages are the descendants of civilized races, and have sunk to their present condition. But Archbishop Whately admits that the civilized races are still rising, while the savages are now stationary; and, oddly enough, seems to regard this as an argument in support of the very untenable proposition, that the difference between the two is due not to the progress of the one set of races, a progress which every one admits, but to the degradation of those whom he himself maintains to be stationary. The delusion is natural, and like that which every one must have sometimes experienced in looking out of a train in motion, when the woods and fields seem to be flying from us, whereas we know that in reality we are moving and they are stationary. But it is argued, "If man, when first created, was left, like the brutes, to the unaided exercise of those natural powers of body and mind which are common to the European and to the New Hollander, how comes it that the European is not now in the condition of the New Hollander?" I am indeed surprised at such an argument. In the first place, Australia possesses neither cereals nor any animals which can be domesticated with

advantage; and in the second, we find, even in the same family, among children of the same parents, the most opposite dispositions—in the same nation there are families of high character, and others in which every member is more or less criminal. But in this case, as in the last, the Archbishop's argument, if good at all, is good against his own view. It is like an Australian boomerang, which recoils upon its owner. The Archbishop believed in the unity of the human race, arguing that man was originally civilized (in a certain sense). "How comes it, then," I might ask him, "that the New Hollander is not now in the condition of the European?" In another passage, Archbishop Whately quotes with approbation a passage from President Smith, of the College of New Jersey, who says. that man, "cast out an orphan of nature, naked and helpless, into the savage forest, must have perished before he could have learned how to supply his most immediate and urgent wants. Suppose him to have been created, or to have started into being, one knows not how, in the full strength of his bodily powers, how long must it have been before he could have known the proper use of his limbs, or how to apply them to climb the tree?" &c. Exactly the same, however, might be said of the gorilla or the chimpanzee, which certainly are not the degraded descendants of civilized ancestors. Having thus very briefly considered the arguments brought forward by Archbishop Whately, I will proceed to state, also very briefly, some facts which seem to militate against the view advocated by him.

First, I will endeavour to show that there are indications of progress even among savages. Secondly, that among the most civilized nations there are traces of original barbarism. The Archbishop supposes that men were from the beginning herdsmen and cultivators. We know, however, that the Australians, Tasmanians, North and South Americans, and several other more or less savage races, living in countries eminently suited to our domestic animals, and to the cultivation of cereals, were yet entirely ignorant both of the one and the other. It is, I think, improbable that any race of men, who had once been agriculturists and herdsmen, should entirely abandon pursuits so easy and so advantageous, and it is still more improbable that if we accept Usher's very limited chronology, all tradition of such a change should be lost. Moreover, even if the present colonists of (say) America or Australia were to fall into such a state of barbarism, we should still find in those countries herds of wild cattle descended from those imported; and, even if these were exterminated, still we should find their remains, whereas we know that no single bone of the ox, or, with one doubtful exception, the domestic sheep, has been found either in Australia or in the whole extent of America. Moreover the same argument applies to the horse, as the fossil horse of South America does not belong to the domestic race. So, again, in the case of plants. We do not know that any of our cultivated cereals would survive in a wild state, though it is highly probable that in a modified form they would do so. But there are many other plants which follow in the train of man, and by which the botany of South America, Australia, and New Zealand has been almost as profoundly modified, as their ethnology has been, by the arrival of the white man. The Maoris have a melancholy proverb, that the Maoris disappear before the white man, just as the white man's rat destroys the native rat; the European fly drives away the Maori fly; and the clover kills the New Zealand fern. A very interesting paper on this subject, by Dr. Hooker, whose authority no one will question, is contained in the Natural History Review for 1864:—"In Australia and New Zealand," he says, "for instance, the noisy train of English emigration is not more surely doing its work than the stealthy tide of English weeds, which are creeping over the surface of the waste, cultivated, and virgin soil, in annually increasing numbers of genera, species, and individuals. *Apropos* of this subject, a correspondent, W. T. Locke Travers, Esq., F.L.S., a most active New Zealand botanist, writing from Canterbury, says, 'You would be surprised at the rapid spread of European and foreign plants in this country. All along the sides of the main lines of road through the plains, a *Polygonum*, called cow-grass, grows most luxuriantly, the roots sometimes two feet in depth, and the plants spreading over an area from four to five feet in diameter. The dock (*Rumex obtusifolius* or *R. crispus*) is to be found in every river-bed extending into the valleys of the mountain-rivers, until these become mere torrents. The Sow-thistle is spread all over the country, growing luxuriantly nearly up to 6000 feet. The water-cress increases in our still rivers to such an

extent as to threaten to choke them altogether.'" The Cardoon of the Argentine Republics is another remarkable instance of the same fact. We may therefore safely assume that if Australia, New Zealand, or South America had ever been peopled by a race of herdsmen and agriculturists, the fauna and flora of these countries would almost inevitably have given evidence of the fact, and differed much from the condition in which they were discovered. We may also assert on a general proposition that no weapons or instruments of metal have ever been found in any country inhabited by savages wholly ignorant of metallurgy. A still stronger case is afforded by pottery. Pottery is not easily destroyed; when known at all it is always abundant, and it possesses two qualities; namely, those of being easy to break, and yet difficult to destroy, which render it very valuable in an archæological point of view. Moreover, it is in most cases associated with burials. It is, therefore, a very significant fact, that no fragment of pottery has ever been found in Australia, New Zealand, or the Polynesian Islands. It seems to me extremely improbable that an art so easy and so useful should ever have been lost by any race of men. Again, this argument applies to several other arts and instruments. I will mention only two, though several others might be brought forward. The art of spinning and the use of the bow are quite unknown to many races of savages, and yet would hardly be likely to have been abandoned when once known. The absence of architectural remains in these countries is another argument. Archbishop Whately, indeed, claims this as being in his favour, but the absence of monuments in a country is surely indicative of barbarism and not of civilization. The mental condition of savages seems also to me to speak strongly against the "degrading" theory. Not only do the religions of the lower races appear to be indigenous, but I have elsewhere pointed out that, according to almost universal testimony of all writers on savages—merchants, philosophers, naval men, and missionaries alike—there are many races of men who are altogether destitute of a religion. The cases are perhaps less numerous than they are asserted to be, but some of them rest on good evidence. Yet I feel it difficult to believe that any people which had once possessed a religion would ever entirely lose it. Religion appeals so strongly to the hopes and fears of men—it takes so deep a hold on most minds—it is so great a consolation in times of sorrow and sickness—that I can hardly think any nation would ever abandon it altogether. Where, therefore, we find a race which is now ignorant of religion, I cannot but assume that it has always been so. I will now proceed to mention a few cases in which some improvement does appear to have taken place. According to M'Gillivray, the Australians of Port Essington, who, like all their fellow-countrymen, had formerly bark canoes only, have now completely abandoned them for others hollowed out of the trunk of a tree, which they buy from the Malays. It is said that the inhabitants of the Andaman Islands have recently introduced outriggers. The Bachapins, when visited by Burchell, had just commenced working iron. According to Burton, the Wajiji negroes have recently learned to make brass. In Tahiti, when visited by Captain Cook, the largest morai, or burial-place, was that erected for the then reigning Queen. The Tahitians, also, had then very recently abandoned the habit of cannibalism. Moreover there are certain facts which speak for themselves. Some of the North American tribes cultivated the maize. Now the maize is a North American plant; and we have here, therefore, clear evidence of a step in advance made by these tribes. Again, the Peruvians had domesticated the llama. Those who believe in the diversity of species of men may endeavour to maintain that the Peruvians had domestic llamas from the beginning. Archbishop Whately, however, would not take this line. He would, I am sure, admit that the first settlers in Peru had no llamas, nor, indeed, any other domestic animal, excepting probably the dog. The bark cloth of the Polynesians is another case in point. Another very strong case is the boomerang of the Australians. With one doubtful exception this weapon is known to no other race of men. We cannot look on it as a relic of primeval civilization, or it would not now be confined to one race only. The Australian cannot have learned it from any civilized visitors for the same reason. It is therefore, as it seems to me, exactly the case we want, and a clear proof of a step in advance—a small one if you like—but still a step made by a people whom Archbishop Whately would certainly admit to be true savages. The rude substitutes for writing found among various tribes, the wampum of the

North American Indians, the picture-writing and Quippu of Central America, must be regarded as of native origin. In the case of the system of letters invented by Mohammed Doalu, a negro of the Vei country, in West Africa, the idea was no doubt borrowed from the missionaries, although it was worked out independently. In other cases, however, this cannot, I think, be maintained. Take that of the Mexicans. Even if we suppose that they are descended from a primitively civilized race, and had gradually and completely lost both the use and tradition of letters—to my mind, by the way, a most improbable hypothesis—still we must look on their system of picture-writing as being of American origin. Even if a system of writing by letters could ever be altogether lost—which I doubt—it certainly could not be abandoned for that of picture-writing, which is inferior in every point of view. If the Mexicans had owed their civilization, not to their own gradual improvement, but to the influence of some European visitors, driven by stress of weather or the pursuit of adventure to their coasts, we should have found in their system of writing, and in other respects, unmistakeable proofs of such an influence. Although, therefore, we have no historical proof that the civilization of America was indigenous, we have in its very character evidence, perhaps, more satisfactory than any historical statements would be. The same argument may be derived from the names used for numbers by savages. I feel great difficulty in supposing that any race which had learnt to count up to ten would ever unlearn a piece of knowledge so easy and yet so useful. Yet we know that few, perhaps none, of those whom Archbishop Whately would call savages, can count so far. No Australian language contained numerals for any number beyond four; the Dammaras and Abipones use none beyond three; some of the Brazilian tribes cannot go beyond two. In many cases where the system of numeration is at present somewhat more advanced, it bears on it the stamp of native and recent origin. Among civilized nations, the derivations of the numerals have long since been obscured by the gradual modification which time effects in all words; especially those in frequent use, and before the invention of printing. And if the numerals of savages were relics of a former civilization, the waifs and strays saved out of the general wreck, though we could not expect to trace them up to that original language, which in such a case must have existed, yet we certainly should not find them such as they really are. I cannot, of course, here give to this argument all the development of which it is capable, or bring forward all the cases in point; but I will quote a short passage from a very interesting lecture delivered before the Royal Institution by my friend Mr. Tylor, in which some of the facts are clearly stated. "Among many tribes of North and South America and West Africa are found such expressions as—for 5, 'a whole hand;' and for 6, 'one to the other hand;' 10, 'both hands;' and 11, 'one to the foot;' 20, 'one Indian;' and 21, 'one to the hands of the other Indian;' or for 11, 'foot 1;' for 12, 'foot 2;' for 20, 'a person is finished;' while among the miserable natives of Van Diemen's Land the reckoning of a single hand, viz. 5, is called *puganna*, 'a man.'" For displaying to us the picture of the savage counting on his fingers, a being struck with the idea that, if he describes in words his gestures of reckoning, these words will become a numeral, perhaps no language approaches the Zulu. Counting on his fingers, he begins always with the little finger of his left hand, and thus reaching 5, he calls it "a whole hand;" for 6, he translates the appropriate gesture, calling it *tatisitupa*, "take the thumb;" while 7, being shown in gesture by the forefinger, and this finger being used to point with, the verb *komba*, "to point," comes to serve as a numeral expression, denoting 7. Here, then, surely we have just the evidence which Archbishop Whately required. These numerals are recent, because they are uncorrupted, and they are indigenous, because they have an evident meaning in the language of the tribes by whom they are used. Again, we know that many savage languages are entirely deficient in such words as "colour," "tone," "tree," &c., having names for each kind of colour, every species of tree, but not for the general idea. I can hardly imagine a nation losing such words if it had once possessed them. Other similar evidence might be extracted from the language of savages; and arguments of this nature are entitled to more weight than statements of travellers, as to the objects found in use among savages. Suppose, for instance, that an early traveller mentioned the absence of some art or knowledge among a race visited by him, and that later ones found the natives in pos-

session of it. Most people would hesitate to receive this as a clear evidence of progress, and rather be disposed to suspect that later travellers, with perhaps better opportunities, had seen what their predecessors had overlooked. This is no hypothetical case. The early Spanish writers assert that the inhabitants of the Ladrone Islands were ignorant of the use of fire. Later travellers, on the contrary, find them perfectly well acquainted with it. They have, therefore, almost unanimously assumed, not that the natives had made a step in advance, but that the Spaniards had made a mistake; and I have not brought this case forward in opposition to the assertions of Whately, because I am inclined to be of the same opinion myself. I refer to it here, however, as showing how difficult it would be to obtain satisfactory evidence of material progress among savages, even admitting that such exists. The arguments derived from language, however, are liable to no such suspicions; but tell their own tale, and leave us at liberty to draw our conclusions.

I will now very briefly refer to certain considerations which seem to show that even the most civilized races were once in a state of barbarism. Not only throughout Europe, not only in Italy and Greece, but even in the so-called cradle of civilization itself—in Palestine and Syria—in Egypt and in India—the traces of the stone age have been discovered. It may, indeed, be said that these were only the fragments of those stone knives &c. which we know were used in religious ceremonies long after metal was in general use for secular purposes. This indeed reminds one of the attempt to account for the presence of elephants' bones in England, by supposing that they were the remains of elephants which might have been brought over by the Romans. But why were stone knives used by the Egyptian and Jewish priests? Evidently because they had been at one time in general use, and there was a feeling of respect which made them reluctant to use the new substance in religious ceremonies. There are, moreover, other considerations which point very decidedly to the same conclusion. It is well known that among various savage tribes female virtue is looked on with a very indifferent eye. Some savages have not—I will not say have not arrived at—the idea of marriage. I cannot here bring forward the evidence in support of this statement, but every one who has taken any interest in the lower races of men will admit that a savage's wives are essentially a part of his property, as much so as his dog or his other slaves; and hence, when a man dies, his brother takes possession of the widow, together with the rest of the property. In those cases where women are treated with rather more justice, the first results are, according to our ideas, of doubtful advantage. Among the Andaman Islanders, for instance, the man and woman remain together only until the child is born and weaned, when they are free to separate and pair with others. In other cases, marriage may be terminated at the wish either of the husband or the wife. In others, again, the tie is of such a nature that it affords not even a presumption as to parentage. The result of this is that many savages have no idea of any relationship by paternity; they recognize kinship through the female line only. This is the case with the Australians, the Fijians, and indeed the South Sea Islanders generally; the ancient Celts, Greeks, the Kasias, Nairs, and other tribes in Hindostan; some of the Cossack hordes, many negro tribes, &c., and traces of it occur all over the world. For the same reason a man's heirs are not his own children, but those of his sisters; while, probably again for the same reason, the Wanyamwezi have the (at first sight) inexplicable custom that a man's property goes to his illegitimate children, and not to his lawful offspring. Thus, then, by tracing up the gradual construction of the idea of marriage, we can account for the two extraordinary customs which we find in every part of the world—that a man is regarded as no relation to his own children, and that his property goes not to them, but to those of his sisters. As things improved, and the probability of parentage became greater, kinship through females only would gradually be abandoned. Many savages have not yet advanced so far, others have recently made the change—as, for instance, the Ait-Iraten, who did so less than a century ago, and erected a stone pillar in memory of the event. Even, however, among the most civilized nations, we find in early history traces of this progression. Thus among the early Jews, Abraham married his half-sister. Nahor married his brother's daughter, and Amram married his father's sister. Here we see the system of kinship through females only. These women were not at that time re-

garded as relatives, though at a later period in Jewish history they would have been so. The custom that when a man died childless his brother married the widow is another case in point, as also is the touching story of Ruth and Boaz, and the sad history of Tamar. Similar considerations, as Mr. M'Lennan points out in his excellent book on Primitive Marriage, prove that the Romans were "at one time *in pari passu* as regards the administration of justice with many races, which we find ignorant of legal proceedings, and dependent for the settlement of their disputes on force of arms or the good offices of friends;" while, as regards marriage, we find customs both among the Greeks and Romans which point back to the time when those polished peoples were themselves mere savages. Even among ourselves a man is, in the eye of the law, no relation to his own children unless they are born in wedlock. He is related to his own offspring not by blood, but through his marriage with the mother. If marriage has not taken place they have no right to his name; and should he leave them any of his property, the State steps in and claims one-tenth, as in cases where money is left to those who are no relations. Thus, then, we can trace up among races in different stages of civilization every step, from the treatment of woman as a mere chattel to the sacred idea of matrimony as it exists among ourselves, and we find clear evidence that the gradual change has been one of progress and not of degradation. Civilized nations long retain traces of their ancient barbarism; barbarous ones, no relics of previous chivalry. As the valves in the veins indicate the direction of the circulation, so can we trace the gradual progress of respect for women, which is one of the noblest features of our modern civilization. Before quitting this interesting subject, I may add that many nations have traditions of the origin of marriage. Among the Egyptians it is attributed to Menes, among the Chinese to Folhi, the Greeks to Cecrops, the Hindoos to Svetaketu. If the idea of marriage had been coeval with our race, if marriage had always appeared as natural, I might say as necessary, as it does to us, such traditions could scarcely have arisen. In the publications of the Nova Scotian Institute of Natural Science is an interesting paper by Mr. Haliburton on "The Unity of the Human Race, proved by the universality of certain superstitions connected with sneezing." "Once establish," he says, "that a large number of arbitrary customs, such as could not have naturally suggested themselves to all men at all times, are universally observed, and we arrive at the conclusion that they are primitive customs, which have been inherited from a common source; and, if inherited, that they owe their origin to an era anterior to the dispersion of the human race." To justify such a conclusion, the custom must be demonstrably arbitrary. The belief that two and two make four, the division of the year into twelve months, and similar coincidences, of course, proves nothing, and I very much doubt the existence of any universal, or even general, custom of a clearly arbitrary character. The fact is that many things appear to us arbitrary and absurd because we live in a condition so different from that in which they originated. Many things seem natural to a savage which to us are unaccountable. Mr. Haliburton brings forward as his strongest case the habit of saying "God bless you," or some equivalent expression, when a person sneezes. He shows that this custom, which I admit appears to us at first sight both odd and arbitrary, is ancient and widely extended. It is mentioned by Homer, Aristotle, Apuleius, Pliny, and the Jewish rabbis, and has been observed in Florida, in Otaheite, and in the Tonga Islands. That it is not arbitrary, however, Mr. Haliburton himself shows, and it does not therefore come under his rule. A belief in invisible beings is very general among savages, and while they think it unnecessary to account for blessings, they attribute any misfortune to the ill-will of these mysterious beings. Many savages regard disease as a case of possession. In cases of illness they do not suppose that the organs are themselves affected, but that they are being devoured by a god. Hence their medicine men do not try to cure the disease, but to extract the demon. Some tribes have a distinct deity for every ailment. The Australians do not believe in natural death. When a man dies they take for granted that he has been destroyed by witchcraft, and only doubt who is the culprit. Now a people in this state of mind—and we know that almost every race of men is passing or has passed through this stage of development—seeing a man sneeze, would naturally and almost inevitably suppose that he was attacked

and shaken by some invisible being; equally natural is the impulse to appeal for aid to some other invisible being more powerful than the first. Mr. Haliburton admits that a sneeze is "an omen of impending evil;" but it is more—it is evidence which, to the savage mind, would seem conclusive that the sneezer was possessed by some evil-disposed spirit. Evidently, therefore, this case, on which Mr. Haliburton so much relies, is by no means an "arbitrary custom," and does not therefore fulfil the conditions which he himself laid down. He has incidentally brought forward some other instances, most of which labour under the disadvantage of proving too much. Thus he instances the existence of a festival in honour of the dead, "at or near the beginning of November." Such a feast is very general, and as there are many more races holding such a festival than there are months in the year, it is evident that in several cases they must be held together. But Mr. Haliburton goes on to say, "The Spaniards were very naturally surprised at finding that, while they were celebrating a solemn mass for All Souls on the 2nd of November, the heathen Peruvians were also holding their annual commemoration of the dead." This curious coincidence would, however, not only prove the existence of such a festival "before the dispersion" (which Mr. Haliburton evidently looks on as a definite event, instead of a gradual process), but also that men were at that epoch sufficiently advanced to form a calendar and keep it unchanged down to the present time. This, however, we know was not the case. Mr. Haliburton again says, "The belief in Scotland and Equatorial Africa is found to be almost precisely identical respecting there being ghosts even of the living, who are exceedingly troublesome and pugnacious, and can be sometimes killed by a silver bullet." Here we certainly have what seems to be an arbitrary belief, but if it proves that there was a belief in ghosts of the living before the dispersion, it also proves that silver bullets were then in use. This illustration is, I think, a very interesting one, because it shows that similar ideas in distant countries owe their origin, not "to an era before the dispersion of the human race," but to the original identity of the human mind. While I do not believe that similar customs in different nations are "inherited from a common source," or are necessarily primitive, I certainly do see in them an argument for the unity of the human race, which, however, be it remarked in parenthesis, is not necessarily the same thing as the descent from a single pair.

In conclusion, then, while I do not deny that there are cases in which nations have retrograded, I regard these as exceptional instances. The facts and arguments which I have here very briefly indicated might have been supported by many other illustrations which I could not bring before you without unduly extending a communication already somewhat too long. They, however, I think, afford strong grounds for the following conclusions—namely, that existing savages are not descendants of civilized ancestors; that the primitive condition of man was one of utter barbarism; that from this condition several races have independently raised themselves. These views follow, I think, from strictly scientific considerations. We shall not, however, be the less inclined to adopt them on account of the cheering prospects which they hold out for the future. If the past history of man has been one of deterioration, we have but a groundless expectation of future improvement; but, on the other hand, if the past has been one of progress, we may fairly hope that the future will be so too; that the blessings of civilization will not only be extended to other countries and other nations, but that even in our own land they will be rendered more general and more equable, so that we shall not see before us always, as now, multitudes of our own fellow-countrymen living the life of savages in our very midst; neither possessing the rough advantages and real, though coarse, pleasures of savage life, nor yet availing themselves of the far higher and more noble opportunities which lie within the reach of civilized man.

The Physical Geography of Nicaragua with reference to Interoceanic Transit, By Capt. M. F. Maury.

The great importance of one or more good commercial highways across Central America being admitted, the question resolved itself, besides cost, into a question of the facilities of ingress and egress by sea, to and from the opposite ter-

mini,—which is an affair of winds and currents. Panama has the advantage in shortness of *land* transit; Nicaragua in winds, terminal ports, and climate. As a rule, the prevailing winds, in the belt of ocean between 35° N. and 35° S., are from the eastward, except the belt of equatorial calms, which extends across the Pacific. Looking westward, therefore, towards Australia or Eastern Asia, Panama is to windward; the commercial routes from thence westward are thus to leeward, whilst the return voyages are to windward. By making a detour, the return voyage would not be so difficult, but other physical difficulties stand in the way of navigation. Panama lies in the equatorial belt of calm, which is greatly widened on the Pacific coast, and sailing-vessels are often detained for weeks by it. H.M.S. 'Herald' was once obliged to be towed by a steamer for 700 miles out of this calm-belt before she could find a breeze. Vessels, therefore, to get clear of the calms in the season in which they prevail, even when their destination is southward, are obliged to move up the coast towards Costa Rica, and then get northward until they reach the N.E. trade-winds, on which they depend for getting out to sea, clear of the calms. This peculiar feature decides the question of the most desirable route across the Isthmus, which would be in a latitude where the calms would not surround the port of the Pacific terminus, and so cause no obstacle to the approach and departure of sailing-vessels throughout the year. Several routes have been proposed across the northern portions of the Isthmus, lying out of the region of calms. On an examination of the physical conditions of each, and especially the winds at the ports of each terminus, the author gives the preference to a route which would cross Nicaragua near to the north-west end of the Lake of Nicaragua, and terminate at the Port of Realejo. Realejo is on the northern verge of the tedious calms of Panama, and the point where they nearly cease to be vexatious to the navigator at any season.

International Pre-historic and Anthropological Congress. *By* Sir R. I. Murchison, *Bart., K.C.B., F.R.S.*

Sir R. I. Murchison read a letter from M. Lartet announcing that at the sitting of the International Congress of Pre-historic Archæology and Anthropology, held at Paris on the 29th of August, it was resolved to hold the Meeting of 1868 in England, and that Sir R. I. Murchison had been elected President thereof. Upon this, Sir Roderick explained to the Section that he had replied to M. Lartet, stating that he was under the necessity of declining the honourable post assigned to him, as he had already made arrangements, on account of the state of his health, to be absent from England during the ensuing summer. He therefore suggested that Sir Charles Lyell, Sir J. Lubbock, Prof. Busk, Mr. J. Evans, Mr. Prestwich, and Mr. A. Franks should be a Committee, with which he would gladly cooperate to organize the arrangements and fix the place and date of meeting*.

Observations on the Livingstone Search Expedition now in progress. *By* Sir R. I. Murchison, *Bart., K.C.B., LL.D., F.R.S.*

Sir R. Murchison explained at some length the various reasons which had led him to disbelieve the story of Dr. Livingstone's death, as narrated to the Consul at Zanzibar and Dr. Kirk by Moussa, the Johana man, the sole witness of the catastrophe. Having given several proofs of the mendacity of this Moussa, he specially dwelt upon his gross prevarication in having given to one of the sepoys of the expedition an account of the death of Livingstone entirely differing from that which he gave to the Consul at Zanzibar. Under these circumstances Sir R. Murchison had felt it to be his duty as President of the Royal Geographical Society, to induce the Council of that body to appeal to Her Majesty's Government to fit out, at small cost, a searching-boat expedition, which, to their great credit, the Admiralty had effectively carried out. He described the pieced structure of the steel boat which had reached the Cape of Good Hope, to be thence transmitted to the mouth of the Zambesi river. He then explained how it was to

* It has subsequently been arranged that Sir John Lubbock is to be the President, and that this Congress will assemble at Norwich in August 1868, during the Meeting of the British Association.—February 1868.

be there put together and manned by natives under the command of Mr. Young, of the Royal Navy, the zealous warrant officer who had during upwards of two years commanded the 'Pioneer' under Dr. Livingstone himself. With two other acclimatized British seamen, and accompanied by a volunteer, Mr. Falkner, Mr. Young was directed to ascend the Zambesi to the mouth of its great affluent the Shire. There the boat would be taken to pieces and carried up on the sides of those great and long rapids to which Livingstone had attached the name of the Murchison Falls, at the head of which it would be reconstructed in order to ascend the Shire, to the most western end of the Great Lake Nyassa, near to which is the spot where, as reported, the great traveller was killed. Having ascertained the true facts, it was estimated that the expedition would on its return reach the mouth of the Zambesi at the end of November, and hence it is hoped that in January of 1868 the painful suspense of the public will be set at rest*.

"If," Sir Roderick added, "we can only ascertain that my valued friend was not killed at that spot, but passed on towards the interior accompanied by a few negroes only, why then I shall have every hope that Livingstone, who can overcome obstacles that not a man in a million can face, and who traversed and retraversed South Africa with black men only, having been also reported to be dead, may emerge from all his difficulties, and settle the great problem now in agitation—whether the vast lake Tanganyika is or is not a great southern water-basin of the Nile."

Description of Two Routes through Nicaragua. *By* Lieut. S. P. Oliver, *R.A.*

The author described a journey he had made, between the months of February and July of the present year, up the river San Juan in Nicaragua, and across the new line overland, between the Lake and the Gulf of Mexico, which has just been cleared through the forest in preparation for a railroad projected by Capt. Bedford Pim. The tract of country traversed was, until the present expedition, a *terra incognita*, occupied by vast impenetrable forests of gigantic trees, dense underwood, and entangled woody creepers. The line commences on the Lake of Nicaragua, at San Miguelito, and ends at the Rama river, in the Gulf of Mexico. At San Miguelito, the variation of the compass was ascertained to be 4° 30′ east.

Exploration of the Grand Chaco in La Plata, with an Account of the Indians. *By* W. Perkins.

On the Mining District of Chontales, Nicaragua. *By* Capt. Bedford Pim, *R.N.*

In its phyiscal aspect, Nicaragua may be divided into three longitudinal sections:—1. The Atlantic side, which is, for the most part, low and alluvial, intersected by numerous rivers, having bars at their mouths, with lagoons inside affording an almost uninterrupted water navigation. The land is everywhere rich, and well adapted to the production of Sea-Island cotton. 2. The Pacific side, having precipitous shores, and no river worthy of the name. The region is eminently volcanic, and destitute of minerals. A curious feature is the number and extent of the lakes spread over its surface, including Lake Nicaragua, ninety miles wide by forty broad. The small lake Nijapa presents some marked peculiarities; the specific gravity of its water is 1·8, and it is hot to the taste, acrid, and smelling of sulphuretted hydrogen. It is of a light greenish-yellow colour, very thick and turbid, and on being kept some time deposits a black precipitate, consisting chiefly of iron. Some of the lakes are fathomless, and pure as crystal. 3. The last section consists of the dividing ridge between the other two, attaining a maximum elevation of 5000 feet. In this district gold and silver are found, and in its southern part lie the mines of Chontales. A dense, unbroken primæval forest covers the greater part of this region, containing a profusion of valuable timber trees, such as cedar, mahogany, sapota, leopard wood for cabinet work, canilla (an

* It is now happily known that the expedition was not only eminently successful in negativing the accounts of the death of Livingstone, but that everything was accomplished within the estimated period, thanks to the skill and energy of Mr. Young.—February 4, 1868.

easily worked wood), venaca (a light sort of boxwood), &c. The Atlantic side is very humid—indeed, white residents jocularly remark that it rains thirteen months in the year; but it is not unhealthy, and the strong north-east trade-winds temper the heat of the climate. The Pacific coast region is contrasted with the opposite side by the sharp distinction between the wet and dry seasons, and the stunted growth of the trees. Gold was first discovered in 1850, and was worked in a rude manner near San Juan. It was not, however, till 1864 that political and other circumstances permitted of an accurate examination of the mining district by a party sent out from England, including Mr. W. C. Paul, a mining engineer. The exploration of the forest-clad district commenced at San Miguelito, near the western extremity of Lake Nicaragua. A narrow tract leads hence, *viâ* Acoyapa, Lovogo and Libertad, to the mining district, which lies a little to the east of the watershed between the lakes and the Atlantic, and near the River Mico, a branch of the Blewfields. The San Juan mine, close to the Mico, was examined, and found to be of rich promise, but the method of working it was very inefficient. Holes 25 feet deep were dug, and adits driven on each side of them until water was met with, which caused the abandonment of the excavation, although the lode becomes richer as depth is increased. Various excursions were made in the vicinity of Libertad, and the existence of valuable lodes of gold and silver satisfactorily established. The Indian village of Kinalala, at the head of the navigable waters of the Blewfields river, is the nearest point of embarkation direct for the Atlantic. The absence of a certain, speedy, and secure means of communication with the sea-coast is the only serious difficulty which mining enterprise will have to encounter in the development of these newly discovered mineral resources of Nicaragua.

On the Colony of New Scotland, in Southern Africa. By J. J. PRATT.

This was a description of an elevated district on the eastern slopes of the Drakensburgh mountains, north of Natal, which has lately been opened for European immigration by the Government of the Trans-Vaal Republic. The climate was described to be good, and the land suitable for pastoral purposes.

Exploration of the Isthmus of Darien, with a view to discovering a practical line for a Ship Canal. By M. LUCIEN DE PUYDT.

This paper communicated the scientific results of two explorations of the Isthmus of Darien, made by the author in the years 1861 and 1865, with the object of discovering a practicable line for a ship canal to connect the two oceans. His researches in the first expedition were directed towards the line proposed some seventeen years ago by Dr. Cullen, between the Gulf of St. Miguel and Caledonia Bay, which had been insufficiently explored by the international expedition sent out about that time. The result of this first journey was to confirm the conclusion arrived at by Mr. Gisborn in 1851, namely, that no practicable line exists for an interoceanic canal in this direction. The expedition led by M. de Puydt thereupon returned to France, and in 1864 he was charged by the French Government to organize another party, for the purpose of thoroughly examining the low range of the Andes about sixty miles to the south of the former line, where several small streams discharge themselves into the Atlantic, near the northern arms of the river Atrato. The expedition was formed in New Granada, and, after a toilsome exploration of several months, in 1865 the author succeeded in discovering a break in the Andes, at the upper course of the river Talela, which renders possible the long desired object. One of the chief obstacles anticipated was the opposition of the suspicious and warlike Indian tribes; but M. de Puydt, by judicious management, contrived to enlist their goodwill so far as not to oppose his designs, although they refused to afford him any assistance or information. Having landed his party and *matériel*, he ascended the Tanela as far as practicable, and then proceeded to clear a pathway through the dense forest towards the Cordillera. The laborious task occupied about a month. The author then (August 25), with six companions, left the track, and threaded the forest to the Sierra de Mali, and in the course of a few days came upon a break in the ridge, elevated only from 100 to 140 feet above the sea-level. The gap was traversed, and

from it an uninterrupted view was obtained over the level plains of Darien towards the Pacific Ocean. The Tanela was found winding through the pass, and the stream was tracked down towards the level country, and observations taken of the velocity of its current, so as to obtain data for a calculation of the height of the pass. The paper entered into ample details on the physical geography of the Atlantic side of the Isthmus, on the soundings in the Gulf of Uraba, into which the Atlantic end of the future ship canal will disembogue, and on the climate and natives. The expedition returned to Carthagena on the 3rd of September, 1865.

Account of the Wild Indians inhabiting the Forests of Huanta, Peru. By Professor A. Raimondy.

These Indians belong to the tribe of Campos, or Antis, and are found scattered through the forests of Chunchamayo, Jauja, Pangos, Huanta, and the valley of Santa Ana, near Cuzco. They occupy the country along the shores of the rivers Santa Ana and Tambo, to the point at which they unite to form the Ucayali, where the territory of the Chontaquinros commences. The Campos are of medium stature, although some few are tall: one man measured six feet (Spanish) in height. The head is dolichocephalic. They have prominent cheek-bones; nose of Roman type, but slightly turned up, and with thick septum; eyes lively and expressive, not well-opened, and rather oblique. The females have white teeth; but in the men the teeth are dark, caused by their continually chewing the bark of a species of Bignonia. The men have little or no beard. The hair is black. The colour of the face is reddish or olive-coloured; but in children it is nearly white. The Campos clothe themselves with a wide and sack-like garment of cotton, neatly woven by the women, sometimes having stripes of a reddish colour. It reaches down to the ankles, and has sometimes attached to it a kind of hood for the head, made of the same material. Wherever they go they carry with them, slung over the back, a large cotton bag, the *chaqui*, which contains all their worldly treasures, and is sometimes ornamented with the gay-coloured feathers of birds. The bag invariably contains a bamboo box filled with anatto paste, with which they besmear their faces from time to time, so that the natural colour of the face is seldom seen, the continual painting of the skin with stripes and various patterns of red imparting a permanent red tinge to the countenance. Their dwellings are small and reduced to a mere thatch, some five or six yards in length by four in width, supported on poles fixed in the ground. Under these is the sleeping apartment,—a conical hut, made of a matting of palm-leaves, and looking like a hen-coop. In this confined space, which is almost hermetically closed, they sleep, five or six together, apparently piled one on the top of another, to protect themselves, as they say, from the bites of bats. When the nights are clear, and the Campos are near the shores of a river, they leave their huts and sleep in the open air by the side of a fire, lying naked on the ground, and wrapping their feet in their bags. Whenever the author arrived at a hut, the Campo husband would always make a sign to his wife, who then brought pine-apples or cooked yucas for the guest. Their main food is boiled and roasted yuca (the root of *Manihot utilissima*), and fish or beasts of the chase, as peccaries, and monkeys of various species. Their language is soft to the ear, being full of vowels, and nearly all the words ending in *i*, *u*, or *o*. Their mode of speaking is gentle, often in a singing tone, as if supplicating. There are times when their manner of talking is very different, and in a loud tone of voice. This happens when they have not seen one another for a long time. Descending the Apurimac, on his journey to ascertain its point of junction with the Mantaro, the author arrived one night at a Campo's hut. His party had hardly landed, when the Campos who accompanied him commenced a loud parly with the owner of the establishment. The conversation was long, and sustained at a high pitch of voice, lasting till daybreak the next morning. The subject of conversation was a recital, even to the most trifling matters, of everything that had occurred to the parties since they last met. The Campos count only up to four; when they want to express larger numbers, they hold up their hands, feet, and pieces of stone. As to their religion, no idols or ceremonies were observed. They do not take any care of their dead; stones are tied to the corpse, and it is then thrown into the river. If, when eating

yuca or plantain, the ants eat the rind, they believe the person who has partaken of the food will fall ill. They no not show the humility of demeanour which is seen in Indians of the Quichua race; they are more manly, looking you straight in the face when speaking. The author paid some attention to the form of the cranium in these Indian tribes. When studying skulls of ancient Peruvians, taken from the *Huacas*, or tombs on the coast, his attention was drawn to the position of the orifice of the ear, which, far from being situated more towards the posterior part of the cranium, as in European nations, appears to be carried forward towards the front. Applying this same observation to the crania of the wild Indians now existing, he noticed a great resemblance to those of the ancient race; both show a greater development of the posterior part of the brain than of the anterior. His mode of measurement was by striking three perpendicular lines, with the skull in profile—one passing by the most salient part of the forehead, another by the orifice of the ear, and the third by the most projecting part of the back of the skull. In a Campo skull, the breadth of the ante-auricular part was 76 millimetres, and that of the post-auricular part 92 millimetres.

On the Vlakhs of Mount Pindus.

By Major Robert Stuart, *C.B.*, *F.R.G.S.*

There are fair grounds for believing that the Pindic Vlakhs are descendants of one or more of those tribes which, in the fifth and succeeding centuries, were driven from their homes on the Lower Danube by the incursion of overpowering hordes from the north and east. Their language, although corrupt and debased, with alloys of Sclavic, Greek, and Turkish, still retains the essential characteristics of a Latin dialect; and the syntax and inflections of the verbs still conform in a remarkable degree to the ancient model. Heads and faces of unquestionably Roman type are found amongst them. Sixty years ago there were about 500 Vlakhiote villages, none very small, dispersed throughout the mountains of Epirus, Thessaly, and Macedonia. At present it would be difficult to reckon up half that number, and the population has dwindled to about 45,000 souls. Originally a pastoral people, they have gradually become traders, and most of their chief towns are now centres of commerce and industry. These are Vlakho-Livadhi, near Mount Olympus, Voskopolis of the Dessarets, Metzovo, Syraku, and Calabrites. In the beginning of the present century, Calabrites counted nearly 600 families, and it became known throughout the Levant for the industry, enterprise, and literary culture of its inhabitants. They were self-governed, and free of all Turkish imposts by paying a fixed and moderate annual tribute. This state of things became changed a few years later, by the tyrannous intervention of Ali Pasha Tepeleni, under whose rapacious exactions the community rapidly sunk into poverty and ruin. The story of Calabrites is, with slight variation, that of most of the chief towns of the western Vlakhs. Metzovo was founded by a Vlakh colony as early as the tenth century. It now contains 770 houses, and is the chief town of the Pindic Vlakhs. For several centuries the Vlakhs have been staunch in their adherence to the Eastern Church. In every central village a school is maintained at the expense of the community, the course of instruction embracing modern Greek, reading, writing, and the first rules of arithmetic. But education is confined to the male sex. The Vlakh woman is treated as an inferior being, and from early years is habituated to drudgery and toil: she is naturally robust and handsome. Numbers of Vlakh women come every autumn to Janina, where they contend with the Jews as street-porters. Like all other pastoral tribes, the Vlakhs have their music; and their favourite instrument is a pipe (φλογέρα), made from the wing-bone of a vulture, open at both ends, and pierced with six holes, all on the same side. The player inserts one end into the side of the mouth, and produces notes which may be varied from sharp and shrill to soft and pleasing. The nomade Scythians of old used to play on a similar instrument. The Vlakhs are superior to the Greeks in foresight, perseverance, and application. The lineaments of the old race are not yet lost. Though quiet and inoffensive, when roused to action they give proofs of great daring and enterprise.

On the Districts of Palestine as yet imperfectly explored. *By the* Rev. H. B. Tristram, *F.L.S.*

A Peruvian Expedition up the Rivers Ucayali and Pachitea. *By* Messrs. Wallace and Mayne.

In June 1866 the Peruvian Government sent a steamer from their establishment at Iquitos, on the Upper Amazons, to ascend the Pachitea, an affluent of the Ucayali, with a view to ascertaining whether a free communication could be discovered by water to the town of Mayro, in Southern Peru, at the foot of the Andes, east of Lima. Two of the officers, Tavira and West, were killed and devoured on the banks of the Pachitea, by the savage cannibal Indians of the Cashibo tribe; and in November of the same year a second expedition in three steamers was sent, with the double purpose of avenging the death of the officers and completing the exploration. The expedition was successful; the Indians were severely punished, by an armed party landing in the forest and burning their villages; and the steamers continued up the Pachitea and Palcazu until they reached Mayro, thus settling the practicability of a route by water between Mayro and the mouth of the Amazons—a distance of 3623 miles. Mayro is said to be 325 miles from Lima, and the Government have ordered a road to be made between the two places. Mr. Wallace, one of the authors of the paper, is an English engineer in the service of Peru. The lowest depth of water found on the journey was two fathoms, and the river in its narrowest parts was 80 feet broad.

Recent Discoveries in and around the Site of the Temple at Jerusalem. *By* Capt. C. W. Wilson, *R.E.*

This paper gave a detailed description of the examination made by Lieut. Warren of the inclosure Haram esh Shariff, which contains within its walls the site of the Jewish Temple, and, as some hold, also that of the Holy Sepulchre. With the exception of a deep hollow in front of the Golden Gate, a slight rise towards the north-west corner, and the raised platform in the centre, the surface of the area is almost level, and has an elevation of 2419 feet above the sea-level. During the progress of the survey a large arch, connecting the Haram area with the causeway, was discovered north of the Wailing Place. The arch is one of the most perfect and magnificent remains in the city. Much information was also obtained concerning the ancient water-supply, which was admirably arranged. The water was brought by an aqueduct from the Pools of Solomon, and stored in rock-hewn cisterns, with connecting channels and arrangements for overflow. Several of the cisterns were found to be of great size, varying from twenty-five to fifty feet in height.

Report of the Palestine Exploration Fund. *By* Capt. C. W. Wilson, *R.E.*

This Report was confined to a statement of the manner in which the sum of £100, granted last year to the Fund by the British Association, had been expended. Half of it had been applied towards paying the expenses of Lieut. Warren, R.E., who had charge of the second expedition sent out by the Society. The results might be stated as follows: the construction of a map, on a scale of one inch to a mile, of the highland districts of Judea, to the north-east and south-west of Jerusalem; of the Jordan valley for about sixteen miles north of the Dead Sea; and of a large portion of the plains of Philistia. These surveys, combined with those made in 1865-66 by Wilson and Anderson, gave, for the first time, materials for a correct map of more than three-fourths of the Holy Land, and do much towards removing the reproach that no trustworthy map existed of this most interesting country. The second half of the grant, applied to the purchase of meteorological instruments, had been expended under the superintendence of Mr. Glaisher, and four sets of instruments had been sent to different cities in Palestine. The observations taken at these places will, combined with those taken at Jerusalem, form the basis of an accurate knowledge of the climate of the Holy Land, so remarkable in many respects.

ECONOMIC SCIENCE AND STATISTICS.

Address by M. E. Grant Duff, *M.P., President of the Section.*

Ladies and Gentlemen,—It has been the custom to open the proceedings of this Section by an address, and it has been the custom that that address should be a brief one. I propose, with your permission, to follow both these good customs. This department of the British Association differs from the others. They are occupied exclusively with the study of external nature. We are occupied, as has been truly said, with external nature only in so far as it exerts an influence on the human mind. They treat of physical sciences. Our Section throws its roots, so to speak, deep down among the physical sciences, but is itself devoted to moral science. Looked at in another light, our pursuits form the debateable land between the men of thought and the men of action. In theory, of course, we are given up exclusively to the examination of *things as they are* to *science*. But do we not continually stray over the border line, and wander into the consideration of *things as they should be* into the domain of the *art* of legislation and Government? Those who are familiar with the proceedings of this Section will not, I think, say No; and this intermediate character of our department accounts, I suppose, for the fact that it is from time to time presided over by Members of Parliament, who, votaries of practical politics, cannot pretend to be teachers of the sciences with which this Section is concerned; cannot even pretend to be the fellow-labourers of some whom I see around me, but are content be in this field their disciples and followers. The British Association, founded in 1831, was one of the results of that great upheaval of the national mind, of which the political change which makes the year 1832 so famous was perhaps the most conspicuous symptom. The foundation of the Statistical Society, and of our own Section, both of which I trust have done something to help on the forward movement of the time, came shortly afterwards, and the latter of these events must have very nearly synchronized with the commencement of that remarkable reactionary movement, which, taking its rise in the common room of Oriel, has since so widely and variously influenced English life. An eminent living writer might find perhaps in this fact another illustration of the operation of Systole and Diastole in human affairs. Up to 1856, this Section was exclusively occupied with statistics. In that year, the centenary of the publication of Quesnay's *Maximes Generales*, and 80 years after the appearance of Adam Smith's great work, the kindred subject of Economic Science was wisely added to our programme. Now, then, we are the Section of Economic Science and Statistics. What do these terms mean, and with what sort of subjects will chance visitors who stray into these regions from more popular Sections find us dealing during the next few days? They will find us, in our character of students of Economic Science, dealing with all the phenomena which attend upon, and the principles which regulate the production, the distribution, and the exchange of wealth. If they are quite unfamiliar with those inquiries, they may come prejudiced against us as cold, and hard, and selfish. We deserve, gentlemen, no such character. The considerations to which we call attention, the laws which we point out, must be taken account of by the most humane and by the most imaginative, if their attempts at world-bettering are not to shiver against the realities of life. All human society, as has been well said, rests on a material foundation, "and beneath all systems of Government, and all schemes of public morality, there lies the science of the wealth of nations." The laws which we enunciate are no more and no less hard or imperative than any of the laws with which other Sections have to do. "What," asked Mr. Mill in the House of Commons last year, "is more unfeeling than the attraction of gravitation?" If, however, gentlemen, we claim for Economic Science a very high place, we do not exaggerate its importance. No wise economist ever pretended to explain more than a very limited number of the complicated problems of society and life. No wise economist ever laid himself open to the denunciations levelled by M. Edgar Quinet in his recent brilliant work on the French Revolution against those who fondly fancy that they can account on economical principles alone for that great moral and political earthquake. There surely never was a time in which it was more plainly necessary to popularize this

science. We are told by alarmists that one of the results of Reform will be, that many matters which were considered settled will be reopened, that Protection will again raise her head, and that the ghosts of old fallacies will come back to gibber in the House of Commons. I am one of those who think such fears wildly exaggerated; but surely the mere possibility of our people lapsing into heresies such as those which have seduced men of our race in America and Australia should warn us to diffuse far and wide the broad results of Economic Science. It is to be feared that, even in circles where we might expect better things, there is a very considerable misconception about the real teachings of economists. Who can forget the opposition that was excited by Mr. Cobden's negotiations in France, as if, forsooth, he of all men was going to be false to the principles by the advocacy of which he had put himself in the first rank of contemporary statesmen? Is it surprising that there should be so much hesitation about the acceptance, I do not say of the mere fact of free trade, but of some of its consequences? Count up the schools in which an attempt is made at giving even a glimpse into Economic Science. There are distinguished professors at both Oxford and Cambridge, but how many men are there who leave the great English Universities with any knowledge of it? The Scottish Universities do very little for this peculiarly Scottish science. I do not think I am wrong in believing that no lectures on political economy are ever delivered even in the most laborious and distinguished of Oxford Colleges, the college of Adam Smith. Of the two economical questions to which your President alluded last year, as to those which were, for the moment, chiefly occupying the minds of men—the question of our coal supply, and the state of the money market—the first will, no doubt, slumber till the report of the Royal Commission is given to the world. The other still attracts attention, but the "wheel has come full circle," the periodical reaction has set in, and the vast pile of gold mounts daily higher, waiting for the spirit of confidence to return. Another economical question has, however, come in these last few months into great and painful prominence. I allude, of course, to the question of Trades Unions, and to the relations of capital and labour. The unhappy contests between these natural allies is not the only joint in our armour. Many eminent men have been declaring that England is falling behind other nations in the industrial race, and that a better and more extended technical education has become a necessity. All attempts, however, to give a good technical education will break down if we do not imitate Switzerland and Germany in creating a really good system of elementary and middle-class education. That is the soil in which technical education must grow, and at present that soil is woefully thin in many places. Fortunately, however, the public mind is becoming familiarized with the idea of an educational rate; and if we have an educational rate to assist the poorest, why not a system of graded schools to which all classes may repair if they see fit, and through which a ladder may be built by which merit may climb to the high places of society. How long will English farmers go on paying that the children of their labourers may be educated better than their own? Amongst the measures of the late session, in which this Section may be supposed to take peculiar interest, was the extension to all trades of the principle of the Factory Acts—these Acts which for more than one generation were so stoutly resisted in the name of Political Economy, but which enlightened theory approves and which experience has justified. The comparative ease with which the bills of last Session passed was creditable to the Government, creditable to the interests affected, and, above all, creditable to Mr. Henry Bruce, the Vice-President of the Council in the late Administration, whose abnegation of self in the willing support which he gave to Bills with which his own name will not be associated, was as remarkable as it is, I fear, rare amongst politicians of any party. If it is easy to give a definition of our work as students of Economic Science, which, although, of course, liable to be pulled to pieces by critics, may be taken as fairly correct, how different is the case with our work as Statisticians? Who can define Statistics? "Quicquid agunt homines" in so far as it is susceptible of being recorded and expressed numerically. That definition might, perhaps, be accepted by some, but there would be many gainsayers. Two sets of men long disputed as to which of them was most entitled to the name of Statisticians. There were those who considered Statistics to be equivalent to what

used to be called "Political Arithmetic." There were those who, appealing to the etymology of the word Statistics, and recalling the history of the science, thought that they, and they alone, were entitled to represent themselves as the successors of the great Göttingen professors who first gave a systematic form to this kind of inquiry. The victory has, for all practical purposes, remained with the first of these two bodies of disputants; that is to say, the science naturally tends to become more definite and precise, to restrict itself more and more within the circle of those facts which can be recorded and tabulated. The statistician has scarcely, perhaps, had so many hard words thrown at him as his cousin the economist; but he has all along been coupled with that unpopular character in public disfavour. Those who know nothing else of Mr. Burke know his sentence about "sophists, economists, and calculators." I even remember seeing it quoted in a letter from an innkeeper who had been remonstrated with on account of an extortionate bill. The statistician, however, no less than the economist, can say something in his own justification. Have not vital statistics done much to diminish the uncertainty in providing for families which used so much to increase the anxieties of the trading and professional classes? Have not sanitary statistics, even within the last few years, added very much to the length and comfort both of civilian and military life? Have not judicial statistics done their part in leading the public to accept the doctrine at which the most enlightened criminalists had already arrived by other paths—that crime is best repressed, not by severe, but by rapid and certain punishment? Are not educational statistics at this very moment convincing all intelligent persons in Great Britain that we must at length make "a long pull, a strong pull, and a pull altogether," to get at least a modicum of education conveyed to the whole people? And while I speak of educational statistics, it may not be amiss to recall one curious instance of the want of them which was lately pressed on the attention of Parliament. A highly intelligent witness from Oxford, examined before the Committee which lately sat to inquire into the educational system pursued at the two great English Universities, admitted that there was not at this moment any official document in existence from which the public could arrive at an idea, even approximately correct, of the vast revenues of Oxford and her colleges—revenues which only required to be used in the spirit of her worthier sons to make her incomparably the most efficient, as she is incomparably the wealthiest, university in the world. Surely it is monstrous that we can with the greatest ease find the revenue and the expenditure of the University of Berlin down to the last dollar, and are unable to arrive at even a tolerable guess as to the revenue and expenditure of a similar institution in our own island. The importance of military and naval statistics need not be urged. Would that the most striking result of inquiries into them could be brought home to all minds! Would that every one realized the fearful loss which the vast armaments now kept up are entailing upon Europe! Would that the people of this quarter of the globe would awake to the danger of being surpassed in all the arts of peace by the great nation on the other side of the Atlantic! An American politician came back last autumn from Prussia, declaring that it was impossible to walk ten yards in a Prussian town without meeting a soldier. An English politician came back at the same time from the United States, declaring that he had traversed the country from end to end without seeing even a single soldier. When will monarchs and cabinets and popular assemblies learn that old wisdom of William III., that that nation will hold the balance of power which, in proportion to its strength, "has economized its material resources to the highest point, and acquired the highest degree of moral ascendancy by an honest and consistent allegiance to the laws of morality in its domestic policy and in its foreign relations?" It would not be difficult to point out the obvious and palpable advantages that arise to the community from other branches of statistical inquiry; but, in truth, there is no need, for cavillers would be silent, if not convinced, were it not that our own friends sometimes give an occasion to the enemy. To attempt to draw from statistical facts inferences which they will not bear—to resolve the whole play of social forces into a mere question of numbers and averages—to pretend that figures governed the world, instead of merely helping us to understand how it is governed, is simply to injure the cause which we profess to defend. Those who act in this way are almost as mis-

chievous as those whose reckless abuses of statistical methods have given point to the sneer that nothing is so false as figures except facts—the Rigbys of political life, who manipulate their figures with a view not to arrive at truth, but to obtain a controversial success. There is no poorer triumph than such a one as this, for there is none easier; unless, indeed, it be the triumph attained by fifth-rate theologians when they quote isolated texts against each other, and each remains, in the opinion of his followers, the master of the unhonoured and unprofitable field of strife. It is, however, vain to argue against anything because it may be abused. Of course, a man who deals with statistics, in the spirit of the saying, "Tant pis pour les faits," can make them prove anything; but surely no saying can be further from being the expression of the temper of any man who has a right to call himself a statistician. Perfect openness of mind, a determination to receive every fact with equal favour, a determination to restrain not only all the ordinary disturbing prejudices, but even that love of hasty generalization which is characteristic of many fine intellects, a spirit resigned to collect, one by one, the stones of the temple which a successor may build up,—these are the marks of a true student of this science. I have said something about popularizing economic science. Arguments not less strong, though different, might be alleged in favour of popularizing statistics. It is in this department that we shall find the real value of those men whose habits of mind lead them to take what I may call the old view of the science, the view which found favour with Schlözer, when he said, "Statistics are history in repose; history is statistics in motion." The more the science, properly so called, withdraws itself up the heights of knowledge, the more necessary will it be to have messengers constantly passing to the plains below. It is satisfactory to see useful manuals of statistics being gradually multiplied and getting down into general circulation. The historical 'Almanach de Gotha' has been mother of a numerous progeny, amongst which not the least useful is the Belgian 'Annuaire' of Scheler, and its younger sister in our own country, the 'Statesman's Year Book.' It is strange that, while France has in a kindred class of literature her excellent 'Annuaire des Deux Mondes,' and Germany her 'Europaischer Gelchichtskalender,' we have nothing more cosmopolitan than our very parochial Annual Register. An idea which was some years ago put forward in the 'Saturday Review,' that it would be expedient to bring out a series of politico-historical *Companions* to Mr. Murray's hand-books, has not yet been acted upon, but the realization of so reasonable a project is surely only deferred. One of the greatest attractions of this science is undoubtedly its international character. The first impulse of a statistician who has arrived at what appear to him satisfactory results with regard to a group of facts and figures in his own country, is to see how his conclusions are affected by similar groups of facts and figures in other countries. In so doing, he is necessarily brought into connexion, not only with foreign knowledge, but with foreign men of activity and intelligence, and so becomes one more link in the chain that is binding into our great confederation the progressive nations of the globe. But I am forgetting that I promised to adhere to the good custom of being brief. During the next week we shall listen to many papers upon most important subjects, both in our character of economists and statisticians. I trust we shall not only bring to all an open and unprejudiced mind, but recollect the precept of the Pyrrhonists, "Be sober, and remember to doubt." Working in this spirit, we may perhaps square a stone or shape a rafter which some future "master of those who know" may use in building up a system of politics which may do as much honour to the nineteenth century after, as did that of Aristotle to the fourth century before the Christian era.

On Productive Labour in Prisons as associated with the Reformation of Criminals. By Sir John Bowring, *LL.D., F.R.S.*

The author read a paper, accompanied by the statistics of twenty-one prisons in Great Britain, with the purpose of showing that profit-giving labour in gaols was an all-important auxiliary for producing reformation among criminals. He stated that the Act of Parliament in 1865, which was intended to regulate all the prisons of England, had left incredible incongruities, discrepancies, and contradictions in

various localities, and under the different opinions and practices of visiting magistrates. He showed that the character of the law was far less influential than the mode of administration—that the statistics of prisons have no uniform character, no common system of accountancy—that the returns, when accessible, are frequently unintelligible—that the amount of infliction and the mode of punishment depend much more on the practice of the local magistracy than on the award of the judges, and that parliamentary requirements are utterly inoperative where the inefficiency or resistance of prison officials are associated with indifference, routine habits, or erroneous notions on the part of the justices. A committee, of which Sir John was chairman, was established by order of the Court of Quarter Sessions in Devon, to ascertain whether, under the conditions of the existing Acts of Parliaments, prison labour could be made remuneratory, and at the same time reforming. The Devon County Prison presents one of the most remarkable instances of the utter waste of labour—of the repudiation of labour as a means of instructing and moralizing the convict—of the indiscriminating application of what is called the deterrent system in all its bitterness and severity; grounded on the theory that the criminal ought never to be the subject of pity, but only of punishment—that the prison is to be no school where hope is to enter, but a solitude where trades are to be taught—where industry is not to be encouraged—where there is to be nothing but isolation, profitless labour, and suffering. Country justices have not been remarkable for extreme sensitiveness; but it might be expected that the desire to lessen the county rates, by getting something out of the sweat of the misdemeanant, would have some influence upon prison administration.

The committee circulated two series of questions, one general the other special. The first was intended to elicit the opinions of those who had most attended to questions of prison discipline as to the connexion between labour and reformation—the action of the cellular system—the use of the treadmill, and, generally, the practicability of making labour profitable under present parliamentary requirements. The second question was intended to elicit from various independent sources the results exhibited by the different practices of different gaols.

The various returns attached to the Report of the Devon Committee invite comparisons and present contrasts which would seem impossible (as they are incredible) in a country subject to the same legislation, to the same inspectoral system, a country of inquiry, and in which the topic of prison discipline has been frequently discussed. The simple truth is that the amount of independent action allowed to the county magistracy—the inability of the central authority to cope with local influences—the "independence" and "irresponsibility" of justices of the peace—habits of routine—love of power—"esprit de corps"—fear of innovation and other sinister influences and interests have resisted reforms and maintained abuses to an extent beyond the power of calculation. Take one illustrative fact as regards cost. In the convict prisons of Scotland the annual expenses per head are £7 less than in the convict prisons of England. Another as regards principle. In the sixty prisons in Scotland there is not a single treadmill; there is a unanimity of opinion unfriendly to its use. In the county of Devon at this moment a treadmill is being erected at an enormous cost, and with the declaration of the visiting justices, that it is not believed any profit can be made from it.

The cost of crime in prisons is considerably more than a million sterling per annum; the cost of crime out of prison is tenfold greater. The number of the criminal classes at large is thrice as great as that of the criminal classes in confinement. In England the yearly net expense of the prisoner is more than double that of France, more than treble that in the United States and in many of the best regulated European prisons.

Prison discipline comes under two special heads, the vindictive and the reformatory; in other words, the instruments of pain and pleasure, of fears and hopes to be applied to the eradication or diminution of crime. In some men the desire to punish is stronger than the desire to reform; in some the desire to reform is stronger than the desire to punish. Sound policy would connect the employment of both with a view to maximizing good and minimizing evil; and labour is or ought to be the instrument for accomplishing each of these praiseworthy objects. Now, by the almost unanimous and emphatic consent of the highest authorities,

productive and profitable labour is more reformatory than wasted labour. Sir John Bowring brought overwhelming evidence of this fact, derived from a variety of sources, and from many parts of the world. It seems an almost universally recognized principle that for short sentences labour of the severest and least remunerative character should be allowed; that species of labour should be only introductory to labour less irksome and more profitable. But however inviting, the field of investigation is too wide, and the materials for judgment too multitudinous, to allow of anything like an exhaustive exploration.

On the Consumption of Opium. *By* Dr. Cuthbert Collingwood, *M.A., F.L.S.*

On the Shipbuilding of Dundee. *By* Henry Gourlay.

Shipbuilding has long been an important branch of industry in Dundee, and even at the beginning of the present century the number of vessels built for coasting and over-sea trade was considerable. All these vessels were, of course, built of timber, and about the year 1823 were all propelled by sails. The number and size of the vessels gradually increased, until about the year 1856, when wooden shipbuilding in Dundee may be said to have reached its maximum. In that year Messrs. Alexander Stephen and Son built the 'Eastern Monarch.' This vessel measured 1848 tons, B.M., was classed 14 years A 1 in Lloyd's Register, and at the time was one of the largest, if not the largest, vessel afloat of this high class. It is now nearly thirty years since iron shipbuilding was introduced in Dundee. In the year 1838 Messrs. James Carmichael and Co. built an iron paddle-steamer named the 'Caledonia,' intended for the river traffic between Dundee and Perth. The same firm also built a small iron schooner. These vessels attracted considerable attention at the time, there being very few iron vessels then afloat. After building these two vessels, Messrs. Carmichael discontinued iron shipbuilding, but it was again taken up in 1840 by Mr. Peter Borrie, who built several iron paddle-steamers. Between the years 1842 and 1854, no iron ships were built in Dundee, and during this interval other ports had commenced, and were carrying on the trade with vigour, so that, although Dundee was early in the field, this advantage was lost. In 1854, Messrs. Gourlay Brothers and Co. commenced to build vessels of iron, and since that time the trade has steadily increased, there being now two firms which build entirely with iron, and one which uses iron for the framework. The following Table will show the tonnage of the various kinds of vessels that have been launched in Dundee since the year 1861, and also the tonnage on the stocks in June of this year:—

Wooden sailing-vessels launched since 1861	13,673		
On the stocks, June 1867	748		
		14,421	
Wooden steamers launched since 1861	5,621		
On the stocks, June 1867	520		
		6,141	
Total tonnage of wooden vessels			20,562
Iron sailing-vessels launched since 1861	5,002		
On the stocks, June 1867	1,066		
		6,068	
Iron steamers launched since 1861..............	11,356		
On the stocks, June 1867	1,130		
		12,486	
Total tonnage of iron vessels			18,554
Composite sailing-vessels launched since 1861....	1,847		
On the stocks, June 1867	601		
		2,448	
Total tonnage of composite vessels......			2,448
Total tons			41,564

The value of the vessels represented by this tonnage is about £627,000 sterling, or £104,500 annually, exclusive of the machinery fitted on board the steamers. The average number of men and boys employed in the shipbuilding yards is about 910. The materials of which the vessels are constructed are generally brought from a distance. The iron comes from the north of England and Glasgow; the wood (except the oak, which is grown in the neighbourhood) from the Baltic, America, and India. The chains and anchors are generally manufactured in Newcastle, but the sailcloth and cordage are produced in Dundee. The cost of the carriage of iron and coal is a disadvantage that the Dundee shipbuilder labours under; but it is not a very serious obstacle, as these materials can be carried at a cheap rate by water, and there are advantages to compensate, so that there is no reason why shipbuilding may not be largely carried on in Dundee. Iron as a material for shipbuilding is here, as elsewhere, to a large extent taking the place of wood; for we find that in 1853 there were no iron ships building in Dundee, but for the last six years the tonnage of the iron vessels has not been far short of the wooden ones, whilst there is nearly double the tonnage of iron vessels on hand that there is of wooden ones.

On the various Methods in which our coinage may be Decimalized—the Advantages and Disadvantages of each. By F. P. Fellows, *F.S.A., F.S.S.*

This paper, after discussing the general principles that should guide us in choosing for adoption any methods of decimalizing our coinage, described at length the various plans that had been proposed.

First. We could at once decimalize our money by adopting the American plan of coining a piece equal to 100 halfpence, or 4*s.* 2*d.*, or a dollar; the halfpenny being equal to an American cent, and the 100 halfpence the dollar.

This would be a very simple method, but the objections to it were, that the halfpenny was too high for our lowest coin (the farthing being much used by our poorer classes), and the dollar of 4*s.* 2*d.* was not sufficiently high for our largest coin.

Secondly. There was what was commonly called the penny, tenpenny, and hundredpenny scheme—1 penny being the unit or smallest coin, and 100*d.* or 8*s.* 4*d.* the largest. The same objections applied to this as to the halfpenny and dollar scheme, and if we are to express farthings and halfpence, we still retain vulgar fractions. It had been suggested that the penny might be divided into ten parts, and also that by a slight change in value, this would bring our system into accord with French francs and centimes; the centime being equal to nearly the $\frac{1}{10}$th of a penny, and the 10*d.* to a franc. The evils and difficulties of this scheme were entered upon, and it was maintained that the tenth of a penny was too low for our lowest coin, and would cause an unnecessary number of figures to be written down.

The third scheme discussed, proposed to commence at the half sovereign; the shilling being the tenth, the shilling being again divided into ten parts, and the tenth of a shilling again decimally subdivided; the lowest unit being the $\frac{24}{25}$ths of the half farthing.

The difficulties of the introduction of this scheme were stated to be the same as those of the pound and mil scheme, which was next discussed.

The fourth plan, viz. the pound and mil scheme, proposed to retain the present sovereign, and to consider that, as now, the highest coin of account. Thus we should have the present pound, the florin as the tenth of the pound, a coin of the value of the tenth of a florin (between $2\frac{1}{4}$*d.* and $2\frac{1}{2}$*d.*), and the 1000th of a pound, being $\frac{24}{25}$ths of the present farthing.

This system would disarrange and throw out all our present copper coinage, and the burden of the change would consequently be thrown mainly upon the poorer and least educated classes, and therefore the least able to understand the new system, or to accommodate themselves to it. Respecting the transition period, it was shown that the change would be nearly as difficult as to introduce an entirely new coinage; for that out of the 960 sums that could be paid from one farthing to a pound, only forty, or about 4 per cent, could possibly be paid with the new

coinage; and out of the 1000 sums from one mil to one pound in the new system, only 40, or 4 per cent., could be paid with our present coins. The only sums that could possibly be paid with both the old and new money, would be 6*d.*, 1*s.*, 1*s.* 6*d.*, and so on, by sixpences to a pound; none of the intermediate sums, from ¼*d.* to 5¾*d.*, from 6¼*d.* to 11¾*d.*, could be paid with new coins; and the same difficulties would occur in paying new coinage sums with old money, the present 6*d.* being 25 new mils, and 24 present farthings. This difficulty was of great moment and affected most of the Government departments, as, for instance, the Customs, Excise, and Postage duties based on our copper coinage, that is, on the ¼*d.*, ½*d.* or 1*d.* Thus the Post-office would have to alter its charge for letters, and if (taking its gross receipts at £5,000,000) it decided to charge 4 mils instead of 1*d.* as now, it must consent to lose £200,000 yearly, the circulation remaining the same; or if it charged 5 mils, then this would be equivalent to an additional tax on the people of £1,000,000 yearly.

The same difficulties applied to bill stamps, receipt stamps, to railway, road, canal, and other tolls, and many Acts of Parliament relating to railway, canal, and other companies would have to be modified. It was shown that all the manufacturer's price lists, both for paying their workmen, and for selling from their books of engravings with printed prices attached, would have to be reprinted, that litigation and strikes with the men would probably ensue, and that it would be a very heavy tax on the manufacturers of this country. It was urged that it was unwise to import all these difficulties in addition to those that were inherent on the mere change itself to a decimal system.

The author then pointed out that it was antagonistic to true decimalization to begin at the highest coin, and to call that the *unit*. The unit, like our numeration, should be the commencement of the system, and like it should begin with units, go on to tens, then to hundreds, and on to thousands.

The author then went on to say. "I now proceed to describe a system which I think overcomes the objections and difficulties I have mentioned as affecting the various schemes under consideration.

"In the first place, by the plan I advocate we get rid of vulgar fractions, ¼*d.*, ½*d.*, ¾*d.* The unit begins at the proper point, viz. the lowest necessary coin, the farthing. We can retain in use during the transition period *all* the coins we now have. We could use and write down either the present, or the proposed new coinage, in pounds, shillings, and pence, as we do now, or decimally. No change need be made in trading or in Government transactions. Those who chose could keep their accounts as now, even if they received the new coinage; and those who chose to keep their accounts decimally, could do so, and could still enter decimally the old coinage amounts they received.

"It begins at the farthing. It has been before suggested to begin at the farthing, but the system proposed has some novelties. I would then boldly at once call things by their right names, especially when these names will correctly denote the relation each coin bears to the rest, and when these designations will greatly facilitate the introduction of the decimal system.

"I would make a coin of the value of

1 Farthing, and call it	1 unit.
10 Farthings, " " "	10 units, or 1 decat, or a 10-unit piece.
100 Farthings, " " "	100 units, or 1 centime or cent, or a hundred-unit piece.
1000 Farthings, " " "	1000 units, or 1 mille or mil, or a thousand-unit piece."

The following Table shows the relation the system bears to our present, and to the American coinage, and gives all the coins that would be introduced if the plan were in full operation. At first, however, the coins required would be merely the 10, the 100, and 1000 unit- or farthing-pieces:—

Pieces to be eventually coined.	New system. Mil or 1000 units.	Cent or 100 units.	Decat or 10 units.	Units or farthings.	Old English values. In pence.	In £ s. d.	Equal to American coins as below.
1 unit	...	...	...	1	or ¼	or ¼	½ cent.
2 units	...	..	...	2	½	„ ½	1 cent.
4 „	...	...	...	4	1	„ 1	2 cents.
1 decat or 10 „	...	...	1	0	2½	2½	5 cents.
2 „ or 20 „	...	..	2	0	5	5	10 cents.
4 „ or 40 „	...	...	4	0	10	10	20 cents.
1 cent. or 10 „ or 100 „	...	1	0	0	or 25	2 1	½ dollar.
2 „ or 20 „ or 200 „	...	2	0	0	or 50	4 2	1 „
4 „ or 40 „ or 400 „	...	4	0	0	100	8 4	2 „
1 mil or 10 „ or 100 „ or 1000 „	1	0	0	0	250	1 0 10	5 „

The author proposed that at first merely the decat, cent, and mil should be coined, *i. e.* the 10, 100, and 1000 farthing-piece; that it should be merely made legal and permissive to keep and sue for accounts decimally in units and mils, it being still legal (till the decimal system was well known and introduced) to use pounds, shillings, and pence.

On the Leather Manufacture of Dundee. By FRANK HENDERSON.

On the Condition and Progress of Scotland compared to England and Ireland in Population, Education, Wealth, Taxation, Crime, consumption of Spirits, Savings' Banks, &c. By Professor LEONE LEVI, *F.S.A., F.S.S., Doctor of Political Economy of the University of Tubingen.*

The author came to the following results:—1. That as regards population, Scotland and Ireland are increasing at a much slower rate than England, the effect rather of a lower rate of marriages and an excess of emigration than of a larger mortality. 2. That in education Scotland stands in a higher position than England and Ireland. 3. That property is increasing faster in Scotland than in England and Ireland, the thriftiness and industry of the people being made manifest in a larger accumulation of wealth. Between 1814–15 and 1864–65 the amount to income-tax increased in England at the rate of 128 per cent., and in Scotland at the rate of 153 per cent. Between 1857 and 1865 the amount so charged increased in England at the rate of 31 per cent., in Scotland at the rate of 33 per cent., and in Ireland at the rate of 12½ per cent. 4. That as regards taxation, Scotland pays a larger proportion of revenue now than at any former period relatively to Engand and Ireland. In 1864–66 the proportion borne was 78·8 per cent. by England, 11·9 per cent. by Scotland, and 9·3 per cent. by Ireland, against 83·1 per cent. in England, 8·8 per cent. in Scotland, and 8·11 per cent. by Ireland in 1830–32. 5. That in so far as the relative amount contributed to the revenue can serve as a criterion for the respective number of members in the houses of legislature, it appears that the altered proportion in the taxation borne by Scotland since the Union entitles her to a larger representation than she possesses; whilst in proportion to revenue the relative number of members should be 51·9 England and Wales, 78 Scotland, and 61 Ireland. 6. That as regards pauperism, the number of persons receiving public relief in Scotland is less in proportion than in England, though much in excess of Ireland; a great difference existing in the proportions of paupers relieved in-door and out-door in the three countries. In 1866 the number of paupers in England was in the proportion of 4·38 per cent., in Scotland 4·01 per cent., and in Ireland 0·94 per cent. of the population. In England and Ireland, about 85 per cent. of the paupers were relieved in-door, in Scotland only 5·76 per

cent. 7. That the number of persons committed for trial for indictable offences in Scotland is greater in proportion than in England and Ireland; and though she shows less propensity to offences against property, she stands in an unfavourable position as to offences against the person. In ten years, 1857–66, the average number of persons committed was,—in England 0·938 per 1000, in Scotland 1·11 per 1000, and in Ireland 0·990 per 1000 of the population. The offences against the person were,—in England 12·10 per cent., in Scotland 29·43 per cent., and in Ireland 37·31 per cent. The offences against property without violence were,—in England 74 per cent., in Scotland 48 per cent., and in Ireland 34 per cent. 8. That the common assumption that Scotland consumes more spirits than England is unfounded, when the quantity of spirits in all spirituous beverages consumed is taken into account; and though we may congratulate ourselves on the diminished consumption of gin and whisky, there is reason for warning in the fact that such diminution is more than counterbalanced by the greater quantity of spirits consumed in the other beverages, principally ale and wine. In 1866 the total quantity of spirits consumed in gin and whisky, brandy, beer, wine, cider, &c., was in the proportion of 4·437 gallons per head in England, 2·984 gallons per head in Scotland, and 1·631 gallon per head in Ireland. Of British and foreign spirits there were consumed,—in England 0·864 gallon, in Scotland 1·847 gallon, and in Ireland 0·857 gallon per head. Of spirits in beer, 3·393 gallons per head in England, 1·050 gallon per head in Scotland, and 0·710 gallon per head in Ireland. Between 1857 and 1866 there was an increase in the consumption of spirits thus calculated of $12\frac{1}{2}$ per cent. in England, 23 per cent. in Scotland, and 8 per cent. in Ireland. 9. That during the last ten years the change in the habits of the people as regards the consumption of spirituous beverages was as follows:—

	England. Per cent.		Scotland. Per cent.		Ireland. Per cent.	
	1857.	1866.	1857.	1866.	1857.	1866.
Spirits	21	20	77	62	68	53
Spirits in beer	76	76	21	35	30	44
Spirits in wine	3	4	2	3	2	3
	100	100	100	100	100	100

10. That in so far as the savings of the working classes are represented in the capital deposited in the Savings' Banks, the amount per head in Scotland was 18*s.* 5*d.*, in England 37*s.* 5*d.*, and in Ireland 6*s.* 5*d.* per head. 11. That the passenger traffic on the British railways in 1865 was in the proportion of 23,400 per mile in England, 10,000 in Scotland, and 7200 in Ireland—the proportion travelling by third-class being 76·41 per cent. in Scotland, 58·66 per cent. in England, and 56·86 per cent. in Ireland. 12. That the number of letters delivered by the Post-office was in the proportion of 28 per head in England, 21 per head in Scotland, and 10 per head in Ireland; or in the proportion of 47, 36, and 17 per cent. respectively. 13. That, as a whole, Scotland appears to be advancing rapidly, her position in the United Kingdom being of considerable importance; whilst, if we add that in proportion to the number of her people she has contributed, and does contribute, a large share of eminent statesmen, lawyers, military officers, men of science, and merchant princes, we cannot resist the conclusion that the Scotch possess in a high degree that energy of character, persistency of will, and boldness in action which have rendered Britain supreme among the nations of the world.

On the Obstacles to the Utilization of New-Zealand Flax. *By* W. Lauder Lindsay, *M.D., F.R.S.E., F.L.S.*

The author's propositions are based on

1. The results of observations made during a tour in New-Zealand in 1861–62.
2. A study of the voluminous literature of New-Zealand flax; and
3. A previous study (ten years ago) of the general subject of foreign fibres as substitutes for those currently used in this country in the textile arts.

He *assumes*—

1. That the value of New-Zealand flax—as a fibre suitable for the manufacture of cordage, textile fabrics, and paper—has been established.

2. That in Europe alone there is practically an *un*limited demand for this class of fibre.

3. That in order to such fibre as New-Zealand flax becoming marketable,

A. The supply must be both regular and large.

B. The quality must equal that of the fibres which at present command the market.

C. The cost of production must be such as to leave a considerable margin of profit on its market price.

4. That hence any candidate for preference in the fibre market must submit to be rigorously tested by the following standards:—

A. Amount and regularity of supply.

B. Quality.

C. Market price.

The utilization of New-Zealand flax has been stimulated in every conceivable way,—by the self-interest of colonists and colonial governments; by the attraction of substantial government rewards; by the high prices offered in the British market for good samples of dressed fibre; by industrial exhibitions throughout the world, including New Zealand itself; by the perennial encouragements of the local press. So long ago as 1856, the general government of New Zealand offered premiums to the extent of £4000 for the production of a marketable fibre; the provincial government of Canterbury subsequently offered a bonus of £1000 with the same object; and still more recently, that of Otago has promised a honorarium of £500 for the production of a marketable paper from New-Zealand flax, or other indigenous fibre. None of these premiums has yet been gained. Infinite have been the experiments instituted, the patents taken out, the efforts made to produce a marketable fibre: while at least one special book, printed moreover appropriately on New-Zealand flax-made paper, has been devoted to the subject. Nevertheless no progress has been made beyond the products of the crude art and hand-labour of the Maori with his simple mussel or cockle shell; if, indeed, *his* results have been rivalled by the best specimens of colonial art. The endeavour to give New-Zealand flax a permanent and satisfactory place in European commerce has hitherto been a signal failure.

The author's object is to discuss the causes of this failure—to indicate the combination of circumstances that has hitherto operated in preventing the practical application in the textile arts of a fibre acknowledged by all authorities to possess a high value.

The author's main propositions are the following:—

I. Amount and regularity of supply.

A. There cannot be a sufficiently large or regular supply to meet the requirements, either of the local or European market, till

1. The plant is *systematically cultivated.*

2. Labour is more abundant and cheaper.

B. It remains to be determined by experiment on the large scale:—

1. What are the most suitable forms and circumstances of cultivation—in reference especially to such practical and important points as (*a*) the kind of soil, and (*b*) the artificial aids to growth.

2. What are the methods of cultivation most suitable to those Botanical *species* or *varieties* which possess the finest quality of fibre.

3. What is the best time for cutting down and preparing the leaf.

II. Quality of the fibre.

A. Varies in different *species* of *Phormium* and different *varieties* of *P. tenax.*

But it has yet to be determined what species or varieties yield the finest qualities of fibre, whether in the

a. Cultivated, or } plant.
b. Wild }

B. Is improved by *cultivation.*

This has long been recognized by the Maories, who cultivate, solely for its fibre, the New-Zealand flax plant as carefully as they do their maize or potato as food-plants.

III. Cost of production and market value.

The present scarcity and high value of labour in New Zealand render the cost

of collecting the wild flax plant, of preparing the fibre, and of transporting it to seaports too great to enable the colonist to offer dressed flax in the European market at a price nearly equal to that of Russian flax and other similar fibres, with which it must compete.

The cost of proper cultivation of the plant and proper preparation of the fibre under present circumstances would be still greater.

IV. Suitable processes, chemical and mechanical, have yet to be devised for dressing, bleaching, and dyeing the fibre.

It has been obviously a common error of experimentalists to conclude that the processes and machinery, which have proved successful in preparing *other* fibres, should be equally suitable and successful here.

V. Not only has New-Zealand flax to compete with many fibres of established reputation, which are easily and cheaply produced in countries where labour is abundant; not only, as regards paper-making, must it enter the market against rags and other waste products of civilization, which are necessarily greatly cheaper than a dressed fibre: but it will have to compete with hundreds of fibres of equal, or nearly equal, value, which abound in all our warmer colonies, and occur generally throughout temperate and warm parts of the world, whose applications will be developed in proportion as colonization progresses, and as chemistry and mechanics are brought to bear on processes suitable for their preparation*.

VI. Labour is likely to become cheaper and more abundant in other colonies than New Zealand, which are quite as rich in fibre-producing plants, while the difficulties attending the separation and dressing of the fibre will probably be more speedily overcome in the case of these other plants and fibres.

VII. There is therefore no good ground for the too sanguine anticipations of colonists and colonial governments as to the future high value of New-Zealand flax as an article of colonial *export*. Present data merely afford *encouraging grounds for experiment*.

VIII. One of the most hopeful directions of *experiment* is the *Acclimatization* of the New-Zealand flax plant in countries suited for its growth, where labour is cheaper and the advantages of chemical and mechanical skill are more readily obtained.

Employer and Employed—Capital and Labour. *By* PATRICK MATTHEW.

On the Confectionery and Marmalade Trade of Dundee.
By CHARLES C. MAXWELL.

It is between sixty and seventy years since Dundee marmalade was first manufactured as an article of commerce by the late Mr. James Keiller, and then merely to supply the local and district demand. Gradually, however, the area of its sale extended, not only throughout Scotland, but into England and Ireland, until now, when it may be said that the whole British Isles, a considerable portion of the Continent, and even our most distant colonies, are supplied with it. To give an idea of the extent of this trade, the author stated that the quantity of marmalade made in Dundee at the present time amounts to above 1000 tons annually, for the production of which more than 3000 chests, equivalent to 6000 boxes, of the finest bitter oranges are used. These are imported from Seville, as it has been found that the oranges grown in and around that city possess a peculiar and agreeable aroma, which renders them better adapted for the purpose than those of any other district either in Spain or Italy. When the marmalade is prepared, a sufficient quantity of sugar is added, to preserve it thoroughly, without in any degree impairing the flavour. The author stated that about four hundred persons are directly employed at the Dundee confectionery works, and occupation is furnished to many others in connexion with them. For example, one of the Newcastle potteries is to a large extent engaged in turning out the well-known printed jars for marma-

* Investigations made in 1858 led the author to the conclusion that fibre-producing plants abound throughout all parts of the world that support a phænogamic vegetation at all rich or varied: *Vide* "Substitutes for Paper Material," Scottish Review, October 1858 and January 1859.

lade. Of these there are about one and a half million required every year, costing upwards of £6500. The marmalade season, as it may be called, that is the period during which all that is required of this preserve for the year's supply must be made, usually continues about four months, viz. from the beginning of December to the end of March. The author mentioned that the word "marmalade," is supposed to be derived from an Indian fruit not unlike the orange, called the *Ægle marmelos*, or Indian Bael, from which, at one period, a similar conserve seems to have been made. Besides orange marmalade, other preserves from fruit are extensively manufactured in Dundee, considerable quantities of fruit being grown in the neighbourhood, although far from sufficient to supply the demand. The manufacture of confections is also carried on on a very large scale, and embraces an immense variety of lozenges, comfits, candied peels, &c. The author stated that, in most of the processes connected with the production of these, carefully-constructed steam-machinery is now successfully employed; and the result is a degree of finish, quality, and cheapness which hand-labour could never have attained. The quantity of sugar, chiefly refined, used for the confections, marmalade, and preserves, made in Dundee, it would be difficult to estimate; but it probably amounts to 2000 tons annually.

It may be asked whether this is a healthful occupation to the persons engaged in it; and that question can, it is believed, be confidently answered in the affirmative. It has been ascertained that working among sugar and fruit is not injurious to health, but the reverse, especially when care is taken that the temperature in the work-rooms is duly equalized and cleanliness and ventilation constantly attended to.

On the Utilization or more Profitable Employment of Male Convicts.
By JAMES OLDHAM.

On the Engineering Manufacture of Dundee. By JAMES G. ORCHAR.

The author enumerated the firms engaged in the production of steam-engines, general millwright work, and spinning, weaving and cloth-finishing machinery. The invention of the fan blast or blowing machine, for heating and melting iron, by Messrs. James Carmichael and Co., of Ward Foundry, was described at length, and the invention of a marine reversing gear by the same firm was also referred to.

A photograph of the first locomotive, made in 1833 for the Dundee and Newtyle Railway, was exhibited.

The author next described the invention of the air-engine by the Messrs. Stirling, and concluded his paper with an account of the early engineering and millwright work in Dundee, and statistics of mill-machinery.

On the Prevalence of "Spedalske," or Leprosy, in the Kingdom of Norway. By HENRY J. KER PORTER, *M.R.I.A., Member of the Philosophical Society of New South Wales.*

During a tour in Norway last year (1866), the author visited the Leper Hospitals at Molde and Bergin, and learned that the disease is incurable. Although the disease is neither infectious or contagious, one naturally shrinks from contact with these poor sufferers. Many of the patients whom the author saw were similarly affected to those seen by him at Calcutta and around the outer walls of Jerusalem. Some, whose fingers were contracted, were quite devoid of feeling in their hands; others were suffering from tubercular leprosy. He was assured by the resident Governor at Molde that there were many truly religious persons amongst those patient sufferers. Those who had the use of their hands were occupied in making fishing-nets, or preparing fine cord for that purpose. The disease is hereditary; and though it will occasionally pass over one or two generations, it will appear in a second or third one. Few will be prepared to learn that in Norway there are above 2000 lepers, as will be seen from the following abstract from the official returns furnished to the Government.

Report of the known number of lepers in the kingdom of Norway on the last Nine Census taken, including hospitals.

In 1856	Total number of cases		....	2113
1857	"	"	....	2060
1858	"	"	....	2082
1859	"	"	....	2095
1860	"	"	....	2068
1861	"	"	....	2096
1862	"	"	....	2119
1863	"	"	....	2162
1864	"	"	....	2182

The author exhibited very finely-executed coloured engravings of the patients who were in the hospital at Bergin, and read an extract from a valuable work by W. Boeck, Professor of the Faculty of Medicine at Christiania, and D. C. Danielssen, Doctor "en chef" at Bergen, showing that the bad food and clothing and lodging tended to the increase of leprosy.

On Arbitration in the Nottingham Hosiery Manufacture. By E. RENALS.

Statistics of the Social Condition of Dundee. By A. ROBERTSON.

On the Funds available for developing the Machinery of Education. By Professor J. E. T. ROGERS.

Analysis of the Report upon the state of the Empire of France, presented to the Senate and Legislative Body, February 1867. (*Exposition de la situation de l'Empire, présentée au Sénat et au Corps Législatif, Février* 1867.) *By* Colonel SYKES, *M.P., F.R.S.*

This report contains in detail the statistics and past progress of every department under the Government, and gives a perspicuous and authoritative statement of the French Empire up to February 1867, in all its political, commercial, and social relations, everywhere testifying to progress, and to a gradual relaxation of the old centralizing system, and to opening up in a liberal spirit commercial intercourse with foreign countries; the prosecution of geographical research in different parts of the world, and the patronage of literary and scientific objects at the public expense, is very marked.

On the Population and Mortality of Calcutta. By P. M. TAIT, *F.S.S., F.R.G.S.*

After describing Calcutta, the metropolis of British India, the author gave some interesting statistics, chiefly taken from a report in the census of Calcutta for the year 1866, and signed by A. M. Dowbans, Vice-Chairman of the Justices of the Peace for the town of Calcutta. The population of Calcutta is estimated at 377,924, and in 1850 the population was estimated, from a survey made at the time, at 353,567. Great difficulty was experienced in getting up the last census, in consequence of the prejudices of the natives, but these were eventually overcome and a pretty correct approximation was got. There were 58,892 houses in Calcutta when the census was taken. The population of Calcutta is distributed as follows:—Europeans, 11,224; Mussulmans, 113,059; Hindus, 239,190; the remaining population is made up of Eurasian Greeks, Armenians, Asiatics, Jews, Parsees, Africans, and Chinese. The suburbs of Calcutta are estimated at 250,000, making the grand population of Calcutta not under 629,924. The highest age attained in reference to each class was Europeans, 87; Eurasians, 104; Armenians, 84; Jews, 88; Musulmans, 100; and the Hindus, 116. The mortality of Calcutta, according to creeds, is Christians, 5·19; Hindus, 6·41; Mussulmans, 5·83. From a report by the health officer of the Census Committee, it appears that there were in 1865, 304 deaths amongst an aggregate European population of 11,224, the mortality being thus at the rate of 2·71 per cent. But these figures should be taken with reserve,

as few Europeans remain to die in Calcutta. That which materially swells the mortality of Calcutta is the death-rate prevailing amongst common soldiers and sailors who go ashore into Lall Bazaar and other places of resort, and drinking arrack and other vile compounds, staggering out and remaining in the open air all night, thus bring on almost certain death. In conclusion, the following is the death-rate per cent. per annum amongst various classes in India according to different authorities:—Bengal military, from 1800 to 1847 (Nelson), 2·40; Madras military, from 1808 to 1840 (Davies), 3·28; Madras military, from 1808 to 1857 (Brown), 3 11; European soldiers, from 1800 to 1856 (Farr), 6·68; Eurasians, from 1837 to 1851 (Tait), 2·47. In estimating a comparison of European mortality in India, an essential element is the period of time embraced in the observations. Thus the death-rate during the first quarter, or even half, of the present century, is no just criterion for future guidance. A great change for the better has taken place within the last ten years, and Englishmen may now settle in India with much less cause for apprehension than prior to the era of railways and the establishment of the overland route.

Observations on Community of Language, and Uniformity of Notation, Weights, Measures, and Coinage. By P. H. THOMS.

On the Linen Manufacture in Dundee and its Neighbourhood. By ALEXANDER J. WARDEN.

In Dundee the linen manufacture now embraces cloth made of jute, as well as of flax, and both fabrics are called "linen." Linen was made in Egypt at a very remote period, and the manufacture descended from that wondrous land through Greece, Rome, and Flanders to Britain. In Scotland the linen manufacture was for many ages of an entirely domestic character, and it extended over the length and breadth of the country. Dundee engaged in the linen manufacture "a long time ago;" and since the introduction of mill-spinning, about 1790, if not before, it has been the great seat and centre of the linen trade of Scotland. Until about a century ago the material chiefly spun was flax of native growth; but foreign flax then began to be imported into Dundee, principally from Russia, and now almost the whole of the flax consumed in that town and neighbourhood is from that country. About 1830, a new fibre, of Indian growth (jute), began to be used, and though it made little way for a time, it rose in favour as it became better known, and now it is the great staple of the town. The rapid increase in the consumption of this fibre is remarkable. In 1836 it was 300 tons; in 1846, 9200; in 1856, 31,000; in 1866, 62,000; and this year (1867) it will exceed 65,000 tons, or about 500,000 bales. The consumption of flax in Dundee has not varied much for the past few years, it being about 24,000 tons, and of hemp 1000 tons, making a total of 90,000 tons per annum. In the district around Dundee, about 37,000 tons of flax, 2000 of hemp, and 1000 of jute, in all 40,000 tons, are consumed annually. The total consumption of flax, jute, and hemp in and around Dundee is now, therefore, about 130,000 tons yearly. The cost of the raw material used in Dundee is about £2,500,000, and in the district around £1,750,000; together, £4,250,000. This material is spun into yarn, and the greater part of the yarn is woven into linen in the district. The total annual value of these commodities exported from the town and district is estimated at £8,000,000. The nominal horse-power, number of spindles and power-looms, and the number of persons employed in the spinning-mills and power-loom factories in Dundee and in the district around, and also in the other parts of Scotland, at 1st September 1867, were as follows, viz.—

District.	Horse-power.	Spindles.	Power-looms.	Employees.
Dundee	5822	202,466	7992	35,310
District around	6290	191,452	10,151	28,875
Together	12,112	393,918	18,143	64,185
Other parts	2840	93,661	1774	13,010
Total	14,952	487,579	19,917	77,195

In addition to the persons employed in the mills and factories, there are about 20,000 people engaged in hand-loom weaving, &c., and in the auxiliary branches of the linen trade in Dundee, and perhaps 10,000 in the other districts, making the total number of persons engaged in the linen manufacture of Scotland considerably to exceed 100,000. The capital invested in the mills and factories, and in the bleach-works, calenders, and other auxiliary branches of the linen manufacture of Dundee and district around, buildings, and machinery, is about £6,000,000, and in the other parts of Scotland £1,000,000; together, £7,000,000. The average value of the stock in trade in the hands of importers, manufacturers, and exporters is estimated at £5,000,000. The total capital required to carry on the linen manufacture of Scotland is therefore £12,000,000. The linens made comprise many fabrics, from the finest shirtings, sheetings, and damask, through all qualities of dowlas, osnaburgs, spriggs, padding, ducks, sailcloth, hessians, sacking, bags, bagging, carpeting, floor-cloth, &c., to the coarsest mending and nail bagging. The mills and factories, especially those erected in Dundee within the past few years, are palatial structures, unsurpassed in extent or solidity by any which have yet been constructed elsewhere, and the machinery is as perfect as human ingenuity and money can make it. The various floors are lofty and thoroughly ventilated, and every modern appliance is taken advantage of to render the works salubrious and healthy, and to lessen the labour and increase the comfort of those employed. A visit to one of these works will gratify and instruct all who take an interest in the mechanical industries of the country, or in the sanatorial improvements which are made for ameliorating the condition and preserving the health of factory operatives, and the proprietors will cordially welcome such visitors.

On the Measure and Value of Oats. *By* A. STEPHEN WILSON.

Reasons why the Office of Warden of the Standards should include Standard Weights and Measures of the Metric System in addition to those of the Imperial Weights and Measures. *By* JAMES YATES, *F.R.S.*

The office of Warden of the Standards was created by an Act of Parliament passed in August 1866, called the "Standards of Weights, Measures, and Coinage Act." Its provisions were in accordance with the previous recommendations of the Commission for the Restoration of the Standards (1841), of the Astronomer Royal (1859), and of the Select Committee of the House of Commons (1862). Its main purport was, that a distinct department of Weights and Measures should be established in connexion with the Board of Trade, and that it should be under the control of a warden, or chief officer, whose business should be to compare standards brought for verification, to watch the legislation and practice in our own country, and the course followed in other countries, to provide the standards and other apparatus required for scientific purposes, and, when necessary, to memorialize the Treasury on the steps which ought to be taken.—*First Report of Warden of the Standards*, 1867, p. 15. But, although at the time when this Act was passed the measures and weights of the Metric System were legalized, no provision was made for its use. Hereupon the author of this paper observes:—

"The gradual extension of the use of the Metric System in this country, leading on to its general adoption, as anticipated by the Committee of the House of Commons, shows the necessity of making the same provision for it as for the Imperial Weights and Measures. Metric weights and measures are now made in considerable quantities by English manufacturers, especially in London, Birmingham, and Sheffield. Many of these articles are exported to countries in which the Metric System has been long and exclusively established. With increasing facilities for the manufacture of them, it may be expected that they will form an important branch of our foreign trade. London tradesmen are greatly disappointed to find that the Metric Weights and Measures Act does not protect them in using Metric weights and measures. The manufacturers of such weights and measures apply in vain at the proper offices to have them tested. There is consequently great uncertainty and liability to fraud in their use, even although "the length of a metre and its subdivisions should be marked upon the same bar with the standard yard."

This does not make a provision by which all persons may test the accuracy of their linear measures, and it leaves the weights and the measures of capacity out of the question.

After further insisting on the necessity for additional provisions for the use of the Metric System, he says, that if the newly appointed Standard Commissioners "will pursue the task, which they have well begun, in an enlightened, patriotic, and generous spirit, striving to carry out the recommendations of the Committee of the House of Commons, and thus to instruct the people in the principles of the system, and gradually to introduce it into the various departments of Government, —if they persevere in this course, it will be found that the change will be gladly and thankfully accepted from any Administration which shall have the wisdom and the happiness to introduce it."

The author says that the Committee of the House of Commons "studied the subject under every important aspect, and after a long, laborious, and most intelligent inquiry, decided unanimously to recommend the introduction of the Metric System in the Post-office, in levying the Custom duties, in Government contracts, in the examinations for the Civil Service, in all schools receiving grants of public money, and in all statistical documents; and they foresaw that, by adopting these preliminary measures, and by instructing the people in its principles and practice, the Government would prepare for its universal acceptance. Although the Government has not yet taken action in this direction, yet the system has been constantly making progress by the action of the people themselves."

The author then shows that England is lamentably behind other countries in promoting this great reform, which must, nevertheless, proceed even in this country.

"It is," says he, "my sincere desire that the recently appointed Standard Commissioners may be the honoured instruments of introducing and expediting this great change. My reason is, that I do not think the Government could have made a better appointment." He mentions their names and qualifications, and concludes by expressing his opinion that they were chosen on account of their past services, their eminence as men of science, and their official and social distinction. He trusts that they would not decline the honourable labour, to which the present proposal would invite them, and hopes that the British Association for the Advancement of Science and the International Decimal Association would continue their assistance, and that this popular agency would combine with that of a more official character to accomplish the scheme recommended by the Committee of the House of Commons.

Notes on Seal- and Whale-Fishings as prosecuted by the North-Sea Fleet, hailing from Dundee. By James Yeaman.

This paper was devoted to the description of an important branch of industry prosecuted at Dundee, to provide a necessary ingredient to render jute applicable or workable into its varied appliances.

Whale fishing has been prosecuted in Britain since the beginning of the sixteenth century. Acts of the Legislature were passed for its encouragement, and bounties were paid by the Government to the adventurers, both on the tonnage of the ships and for the tons of oil and bone landed in British ports. During the reign of James VI. of Scotland and of England Acts were passed by the Imperial Parliament to encourage the trade. Its seamen were exempt from impressment for naval service, and bounties on the produce were granted. From the year 1733 to the end of 1785 these bounties amounted for England to £1,064,000, and for Scotland £202,000; the officially declared value of the whale-fisheries imported into England in the forty-one years included between 1760 and 1800 being £2,144,387.

Fish-oil was at that time applied to various purposes, but the chief object was oil for illumination.

The discovery of coal-gas had the effect of lessening the demand for fish-oil, and consequently of the number of ships employed in the North-Sea fisheries; and although never wholly abandoned, the trade dwindled for many years, and only revived when the use of jute, a fibre manipulated under the action of fish-oil, created a new era in the manufacture and production of many useful and ornamental fabrics,

Dundee first engaged in the whale-fishery towards the close of the last century, and had eight vessels employed in it in 1814, varying in size from 270 to upwards of 300 tons burden. The pursuit had proved profitable, as in the year 1839 ten ships were engaged, but from that date for nineteen years the success appears to have varied, the number employed then being reduced to four.

In 1858 the late Mr. William Clark had the full-rigged ship, the 'Tay,' of above 600 tons register, converted into an auxiliary steam-screw whaler, being the first successful introduction of steam power into the pursuit from the port of Dundee.

Next year two new auxiliary screw-steamers, the 'Dundee' and 'Narwhal,' were built expressly for the seal- and whale-fishing. These fine vessels proved the superiority of steam over sail-ships for prosecuting the North-Sea seal and whale fisheries; and since then, through local enterprise and energy, several new powerful steam-whalers have been built, and several sail-ship whalers have been converted into screw-steamers, and added to the Arctic fleet, there being now twelve full-rigged auxiliary screw-steamers of from 400 to 600 tons register employed at the Greenland Seal and Davis Straits Whale fisheries, and no sailing-ship in the trade from Dundee, Dundee ranking foremost in her steam-whale fleet of the ports of Europe or America. The value of this fleet, with full equipments for a season's fishing, with the requisite boiling &c. premises at port on shore, may be roundly estimated at £200,000, and the gross worth of a successful seal- and whale-fishing at £120,000. Fishing by steam is more costly than by sail-ships; but as two voyages can be made in one year by steam, one to the sealing at Greenland and a second to whaling at Davis Straits, with greater facilities, the extra expense is more than counterbalanced.

To accomplish the double voyages, vessels must leave Dundee for the seal-fishing in Greenland waters about the 1st of March, returning to port to discharge their cargoes about the 25th of May; and again sail for whaling at Davis Straits, after being from six to ten days in harbour, as may be required, to discharge the produce of the sealing voyage, and to recoal.

Each ship is equipped with eight fishing row-boats about twenty-five feet long, and is manned with sixty-five to eighty hands for the seal-captures, and fifty to sixty for whaling.

The capture of 3000 seals is considered good work of a ship's crew in a day, but stormy weather renders the number which may be secured very uncertain.

The whale-fishing at Greenland and Spitzbergen is now seldom prosecuted by Dundee ships, that at Davis Straits being preferred.

MECHANICAL SCIENCE.

Address by Prof. W. J. Macquorn Rankine, *C.E., LL.D., F.R.SS. L. & E. &c., President of the Section.*

It is well known that the most important part of the proceedings at the Annual Meetings of the British Association consists in receiving reports of scientific researches made during the previous year, and planning those to be made during the ensuing year, whether by observation and experiment, or by collecting and arranging existing information. The proposals for such researches originate in the Committees of the several Sections, are then considered by the Committee of Recommendations, and are finally sanctioned by the General Committee; and the reports of them are read to the Sections with whom the proposals originated. I think it may be useful on the present occasion to lay before the Meeting a brief summary of the researches which have been made or recorded at the instance of the Mechanical Section since 1850. As that was the year in which I became a member of the Association, I will refrain from extending the summary to earlier years, because that duty would be better performed by some member who took part in the proceedings of those years.

Strength of Materials.—This subject has obtained, as its importance deserves, a large share of the attention of the Section. The following are the reports which the Section has received, and the dates of the meetings at which they were read:—
1. Mechanical Properties of Metals as derived from frequent Meltings, 1853.
2. Tensile Strength of Wrought Iron at different Temperatures, 1856. 3. Resistance of Iron Tubes to Collapse, 1857, 1858. 4. Resistance of Glass Globes and Cylinders to Collapse, 1858. 5. Effect of Vibratory Action and Long-continued Changes of Load on Wrought-Iron Girders, 1860, 1861. Those five reports are the work of Dr. Fairbairn; and they contain solutions of questions of the highest importance, practical as well as scientific. The third of them, in particular, contains the discovery of a new law in the strength of materials—that which connects the resistance of a flue to collapse with its thickness, diameter, and length, and the correct application of which is essential to the safety of steam-boilers: it is this—that the intensity of the pressure on the outside of a tube required in order to make it collapse, varies directly as the square of the thickness nearly, inversely as the diameter, and inversely as the length. The fact of the resistance to collapse varying inversely as the length had never even been suspected until it was brought to light by Dr. Fairbairn's researches; and he also pointed out the remedy for that cause of weakness in the use of stiffening rings for dividing the length of the tube into intervals of a length consistent with safety. The fifth of those reports contains the first determination, with any approach to precision, of the *factor of safety* in engineering structures of wrought iron. (The corresponding factor for cast iron had been determined by the Parliamentary Commissioners on the Application of Iron to Railway Structures.) It had long been well known that the load which structures will bear with safety when repeatedly removed and replaced, and accompanied with vibration and rapid motion, is very much less than the load required to break the structure at once; but the ratio which the latter load bears to the former, called the "factor of safety," had never, until these researches were made, been fixed according to any principle based on a foundation of experiment. 6. Adaptation of Suspension Bridges to Railway Trains, 1857, 1858, by Mr. Vignoles. Along with this report there should be mentioned, as having contributed to the solution of the same question, a paper by Mr. P. W. Barlow, read in 1860. The researches of both these authors relate to the means of enabling suspension bridges to bear heavy travelling loads, by the aid of stiffening framework. 7. Strains in the Interior of Beams, 1862, by the Astronomer Royal. 8. Strength of Materials in Iron-ship-building, 1865, by Dr. Fairbairn. Next follow a series of reports of very high interest, relating to the application of materials to the art of national defence. 9. Durability and Efficiency of Artillery, 1855; a provisional report by a committee, containing suggestions for researches. 10. Resistance of Iron Plates to Pressure and Impact, 1866, by Dr. Fairbairn. 11. Mechanical Properties of Iron Projectiles at High Velocities, 1862, by Dr. Fairbairn. 12. Rifled Guns and Projectiles, 1862, by Mr. Aston. 13. Penetration of Armour-plates and Iron-clad Ships, 1866, by Captain Noble. It is unnecessary to enlarge upon the value and interest of the results recorded in the last-mentioned report, which must be fresh in the recollection of the members, having been read at Nottingham, and printed in the last volume of Reports. Those results constitute the greatest step in advance which has hitherto been made towards accurate knowledge of the quantity of work required in order to pierce a given target with a given projectile, and the quantity of powder required in order to do that work. 14. Mechanical Properties of the Atlantic Telegraph Cable, 1864, by Dr. Fairbairn.

Motive Power.—The obtaining of motive power by means of steam has to a great extent been considered by committees of the British Association in connexion with the propulsion of vessels; and so far it comes under the head of steam navigation, a subject to which I shall presently refer more fully. The following are the Reports relating specially to motive power:—1. On the Vortex Water-Wheel, 1852, by Prof. James Thomson. 2. On Water-Pressure Machinery, 1854, by Sir W. G. Armstrong. These two reports contain valuable information as to two important classes of hydraulic prime movers. 3. On the Density of Steam, 1859, 1860, by Dr. Fairbairn and Mr. Tate. These communications were not printed amongst the Reports, but only in the 'Proceedings' of this Section, being merely abstracts of researches

which appeared in detail in the Philosophical Transactions; but the importance of the results contained in them makes it necessary to refer to them now. Those results constitute the first direct determination of the density of steam; and besides their practical value, they furnish a most remarkable confirmation of the dynamical theory of heat, because they agree very nearly with the densities of steam which had been deduced from the laws of its pressure and latent heat four or five years before, by calculation according to the principles of thermodynamics. 4. Steam-Boiler Explosions, 1863, by the Astronomer Royal, showing the great explosive energy possessed by a mass of liquid water at a high temperature.

It has been established beyond the possibility of doubt, according to the second law of thermodynamics, that the utmost quantity of work which can be got by the expenditure of a given quantity of heat depends solely on the limits of temperature between which the engine works, and is independent of the nature of the fluid to which the heat is applied, such as water, ether, air, ammonia, &c. The means of improving the economy of heat in thermodynamic engines are of three kinds: first, working expansively, so as to obtain from the heat applied to the fluid all the work that is possible between given limits of temperature,—this has probably been already carried to the utmost extent practicable; secondly, increasing the range between those limits of temperature,—to this there are bounds set in practice by the conditions of durability and safety; and thirdly, diminishing the quantity of heat which goes to waste from the furnace. The last is probably the means which at present holds out the greatest probability of improvement upon the economy of the most economical steam-engines of the present time. It is probable that the use of rock-oil as fuel may contribute towards that result; and something may perhaps be hoped from the direct use of the products of combustion to drive the engine. 5. Gun-cotton, 1863–65. In these reports by a Committee, it is shown how gun-cotton is adapted to various purposes by suitable mechanical preparation.

Hydraulic Engineering.—1. On the Water-Supply of Towns, 1855, by Mr. Bateman. A report of great interest, on a subject worthy of the continued attention of the Association. 2. On Rainfall, 1864–66. A series of reports by a Committee, based chiefly on observations collected by Mr. Symons. These will probably be continued annually. 3. On Weir-Board Gauges, 1856, 1858, 1860–61, by Prof. James Thomson. These reports contain the results of experiments on the gauging of the flow of water in streams by means of "notch-boards," showing how accuracy is to be ensured in such gauging; and, in particular, the properties and advantages of triangular or V-shaped notches. 4. Tides on the Trent and Humber, 1864, by Mr. Oldham.

Shipbuilding and Steam Navigation.—1. The Strength of Materials in Iron Shipbuilding, and the Resistance of Armour-plated Ships to Penetration, have been referred to under another head. 2. Tonnage of Ships, 1856–57, by a Committee. 3. Steam Navigation at the Port of Hull, 1853, 1859, 1861, by Mr. Oldham. 4. Iron Shipbuilding on the Tyne, Wear, and Tees, 1863, by Mr. Palmer. The three preceding subjects partake of a statistical as well as a mechanical character. 5. Life-Boats, 1854, by General Chesney. 6. Statistics of Life-Boats and Fishing-Boats, 1857, by Mr. Henderson. 7. River Steamers, 1858, by Mr. Henderson. 8. Mercantile Steam Transport Economy, 1856–57, 1859, 1861, by Mr. Atherton. 9. Shipping Statistics, 1858, by Admiral Moorsom. 10. Resistance of Water to Floating and Immersed Bodies, 1865–66. Report of Experiments, by a Committee. 11. Steamship Performance, 1857–63:—A series of reports of data collected from various quarters by a Committee, presided over at first by the late Admiral Moorsom, and afterwards by His Grace the Duke of Sutherland. Referring more especially to this last-mentioned series of reports (and also to the reports of the experiments of Mr. Scott Russell on Waves, published previously to the period to which this summary is limited), it may be held that the reports and archives of the British Association contain, perhaps, the greatest mass of data of experiment and practice ever brought together for the purpose of improving the science of the designing and propulsion of vessels. The bulk of that mass of information is so great that it was resolved last year to appoint a committee for the purpose of condensing it; and a report by that committee will be laid before this

Meeting. The use of the jet-propeller, first put in practice in 1839 by Messrs. Ruthven, has lately been revived and extended; and in future reports it is highly desirable that examples of its performance should be recorded.

Conveyance.—1. Railway Brakes, 1859, by Dr. Fairbairn. 2. Sound Signals at Sea, 1861, by Prof. Hennessy. 3. Fog Signals, 1863, 1866, by a Committee. All these reports contain results of great importance to the public safety. The attention of the Association was called last year to Mr. Fell's method of ascending steep gradients on railways by the help of a central rail.

Metallurgy.—Although no report upon metallurgy has been presented to this Section within the period to which this summary refers, I consider that it would be incomplete were I not to mention two ordinary communications to the Section, in 1856 and 1865, by Mr. Bessemer, on his method of making iron and steel, a subject to which the Section might well devote a large share of its attention.

Agricultural Machinery.—No report on this subject has ever been laid before the Section, but an ordinary paper was read in 1853 on the history of reaping machines, by Mr. Crosskill. The inventor of the first practically successful reaping machine, the Rev. Patrick Bell, resides at no great distance from Dundee; and I hope that the Meeting may, if possible, be favoured with the presence of so great a benefactor to agriculture.

Reports were made on the following subjects at the instance of the Mechanical Section, in conjunction with various other Sections of the Association:—Weights and Measures, 1864–66. Patent Laws, 1858–59, 1861. Scientific Evidence in Courts of Law, 1866.

Considering the number, the variety, and the extent of the researches—of which, in the limited time at my disposal, I have only been able to give an account so brief that perhaps it deserves the name of a catalogue rather than that of a summary—the labour and skill expended in these researches, and the scientific interest and practical utility of the results to which they have led, I think that the Mechanical Section of the British Association may fairly claim the credit of having exerted itself, not only for the advancement of science, but for the improvement of practice, with industry and with success.

On the Difficulty of obtaining Local Information after reaching the Summits of Eminences from which extensive Views are obtained. By J. VAN-NORDEN BAZALGETTE.

To supply trustworthy topographical information, the author proposed that local indicators should be placed upon summits which are periodically visited by tourists. The Local Topographical Indicator would consist of a circular table of stone or metal, engraved with radial lines pointing in the direction of any object of interest. Upon the line would be engraved the name of the object, its distance from the point of view, and, in the case of mountains, giving their correct height above the sea. A table of three feet in diameter would be sufficiently large to embrace a district of thirty miles in radius, which would generally be found sufficient. To facilitate reference, concentric lines, at distances of five miles, would be engraved upon the table, within which circles the names of places at such distances would appear. Upon an outer circle, the names, directions and distances of large cities, cathedrals, dockyards, headlands, and other objects of interest beyond the thirty-mile circle would be shown. In the centre of the table may be placed a telescope, with an indicating hand, arranged so that on placing the hand in the direction of any object, the object itself, if within the range of sight, would be brought within the field of the telescope. Arrangements are now being made by the author for the erection of a local indicator, with a telescope and light ornamental shelter, upon the summit of the Malvern Beacon Hill, in Worcestershire. The form of the local indicator may be varied according to circumstances. It may be cheaply constructed in cast iron, and with or without the telescope and building. The local indicator would afford to the tourist much of the interest and information which is frequently lost in consequence of fogs enveloping the summit which with difficulty he has reached, and would at once point out the direction for returning —a want which the author has frequently experienced. A smaller and less com-

plicated form of indicator would be useful in open places in large towns, the direction and distances to churches, railway stations, theatres, &c. being given. The tops of letter pillar-boxes being provided with such information, would assist strangers as to distances and cab-fares.

On the Methods for Testing the Speed of Vessels over the Measured Mile. By Admiral Sir E. Belcher, *K.C.B.*

The author pointed out that the trial of a vessel over one mile could not be considered any test of her real speed or capabilities; besides which, he thought the taking the speed should not be entrusted to those on board. He considered that the force and action of the tides had not been duly ascertained, inasmuch as experience had shown him that, while the surface-tide appeared by the buoys to be running a strong ebb, an undercurrent was running flood, and exercising a considerable influence on the body of the vessel immersed. This underneath current he thought would vitiate any results obtained by the course generally pursued for testing the speed of vessels. He would suggest a series of experiments similar to those carried out by himself at Kingston in 1835 to test the strength of this undercurrent. He proposed further that the speed should be tested on *terra firma*, where umpires should decide, by a pair of fixed theodolites, the times of transit. Taking away from those on board any control over the starting moment, he would cause them to indicate by intersections, every ten minutes, the exact course the vessel had pursued. As regards the mode of trial, the run should be for twenty-four hours at least. She should have a supply of coal for thirty hours. At the end of the run, her remaining coal should be carefully measured, the general temperature of the engine-room should be carefully noted, the condition of the paint on her funnel examined, to ascertain whether the firing has been excessive, and a full report should be made as to how she had behaved against a head sea, her easiness of steering, &c.

On Reaping-Machinery. By the Rev. P. Bell.

After giving an account of the modes of reaping corn in use from the earliest times, pointing out how little alteration had been made in them down to modern days, the author narrated the circumstances under which he had been led to give his attention to the subject, and ultimately to succeed in constructing, in the year 1828, a reaping machine, which, although it did not then come into general use, was efficient for the purpose, and which, in fact, was, with scarcely any alteration, the reaping machine of the present day.

On an Iron Camb for Power Looms. By James K. Caird.

On the Birmingham Wire Gauge. By Latimer Clark.

The object of the paper was to point out the necessity for having a recognized standard gauge. The author proposed the appointment of a committee to investigate and report upon the subject. The differences which now existed in the various gauges in use made serious differences in contracts—in one instance in which the author was concerned a money difference of £8000 in one contract.

On J. R. Swan's Improved Calcining Kilns. By J. Eckersley.

The Results of Experiments on the Rigidity of Glass, Brass, and Steel. By Dr. J. D. Everett.

The author described the ingenious arrangements by which the experiments were carried on, and the minute deflections measured. Cylindrical rods, about one-third of an inch in diameter, of flint-glass, drawn brass and steel, were alternately bent and twisted by known couples, so applied that the couple (whether of flexure or tension) was always uniform through the whole length of the rod. The amounts of bending and twisting thus produced in a given portion of the

rod were measured by the aid of two mirrors clamped to the rod. In the earlier experiments, these mirrors were made to reflect a dark line placed in front of a lamp-flame, and the displacements of the images were measured on a screen. In the later experiments, two telescopes were placed almost vertically over the two mirrors, so as to look down into them, and a sheet of paper (cross-ruled) was fixed in a horizontal position overhead. The displacements of the lines on this sheet as seen in the telescopes were then observed. From the measurements of flexure and tension thus obtained, the coefficients of elasticity and rigidity for the substances operated on were calculated.

On the Iron and Steel shown at the Paris Exhibition. By JOHN FERNIE.

The author stated that a great deal had been said about the advance the French had made in this department, but he thought this was erroneous. Coal was sent into France free of duty, and English raw iron with a very small duty. When, however, the English came to send their finished iron into France, it was practically prohibited by the duty imposed. The only iron in the Exhibition from England was from the best Yorkshire houses, and a very few others. He first called attention to the large girders. There were several specimens of these exhibited in the French department, which were larger than any ever rolled in this country. These girders were 3 feet 7 inches in depth, but only 12 feet long—a length wholly inadequate in proportion to their depth. The length for all practical purposes should be at least fifteen times the depth. These were mere *tours de force*. He believed that the process of building up such masses of iron, and the frequent reheatings and coolings necessary for the purpose, would not produce a girder anything like equal to a girder made in the ordinary way—of boiler-plates riveted together. These girders, in the opinion of the author, had been made for the purpose of going beyond the English people, and not so much for their practical value—in short, to excel the English in this respect. Another process of the manufacture was that of stamping, lately introduced, and which has been very largely carried out by the French. This process was to make a complicated forging in small pieces, then fix them together, put it in the furnace, and raise to a welding heat, bring it under an immense die or hammer, and thus complete the process of forging. This process had not come into general use in this country; but one English house had shown several specimens quite equal in manufacture to those exhibited by the French. The manufacture of steel in large masses, exhibited by Krupp and the Bocum Company, far exceeded in size anything as yet manufactured in England. The specimens from the Bocum Company were, in the opinion of the author, deserving of special mention. Twenty-two railway-wheels of cast steel, in one casting, were, he believed, the finest ever exhibited. So far as France is concerned, England had not been excelled in any department in the manufacture of iron or steel.

An Account of Bergstroem's Boring Machine, used at the Perseberg Mines, Sweden. By DR. C. LE NEVE FOSTER.

The author described a small machine for boring holes for blasting. The machine had taken the place of human labour applied to the mallet and ordinary borer or drill. It weighed only 122 lbs., cost £22 10*s*., and was worked by compressed air. The air-compressor, pipes for conveying the air, and other details, were described; and the author then proceeded to an account of the general results which had been arrived at by careful experiment, showing that it had been found that the driving of a level was done twice as quickly by using the machine as it could be done by hand labour, and with a saving of 20 to 25 per cent. in money.

On the Stowage of Ships' Boats. By GEORGE FAWCUS.

On the Application of the Funds derived from Patent-Fees. By G. B. GALLOWAY.

On Steam Cultivation. By DAVID GREIG.

On the Heating of Hot Houses. By JOHN HALLIDAY.

On an Improved Suspension Bridge. By A. S. HALLIDIE, C.E.

On the Application of Machinery to Boring and Tunnelling. By General HAUPT.

The author gave an account of the circumstances under which he had been led to consider the possibility of applying steam to tunnelling, an application which engineers had universally pronounced impracticable, but which he had demonstrated to be not only possible, but, under certain circumstances, highly advantageous. The author then explained the construction of his drilling-engine, the mode of mounting, the appliances for erecting and removing the machines, the power to drive them, the questions of ventilation, lighting, blasting by electricity, and the application of the system to Cornish mining. The construction of the machines was explained by means of diagrams, without which it would be hopeless to attempt a description. On the subject of power, the author discussed the question of compressed air, the loss of power in compression and transmission, the possibility of using steam by the aid of a vacuum-pipe, the superiority of the ventilation, &c. From experiments made by the author at the Franklin tunnel, the enormous loss of power by passage of air through pipes has been practically measured. As an instance of the advantage of using large pipes, it was stated by General Haupt that with 110 square inches of cross-section, 550 horse-power would be required to pass 3674 cubic feet of air per minute through a pipe four miles long, whereas less than ten horse-power would suffice if the pipe had a cross-section of ten square feet. In the course of the reading of the paper, General Haupt alluded to the military railway bridges constructed during the civil war in America, and he explained the system by diagrams on the blackboard, and showed how a bridge had been constructed in four days and a half, chiefly by the aid of negroes, which was 600 feet long, and nearly 100 feet high, the timber being cut from the stump.

On the Iron and Steel at the Paris Exhibition. By FERDINAND KOHN.

The collection of iron and steel in the Paris Exhibition was one of the most complete and instructive representations of the present state of iron metallurgy in all its branches which could have been brought together at any one spot under any circumstances. The writer then spoke of the main cause of the great industrial revolution now witnessed—an invention with which the British Association had an historical connexion—the Bessemer process, which process had been most successful during the eleven years of its existence. He next referred to those much-admired steel castings of Rhenish Prussia, which had caused so much interest and curiosity by their extraordinary sizes and qualities, and he referred to the secrecy and mystification which surrounded their manufacture, arising, in his opinion, from the want of an effective patent law in Prussia. In conclusion, he remarked that the vague notion now existing in Britain that the superiority and predominance of British iron manufacture had ceased to exist, or was threatened to be overthrown by continental competitors, had no foundation, judging by the state of things in the Paris Exhibition.

On an Improved Marine Steam-Boiler. By J. LEWIS.

This boiler is constructed with a series of undulating flues, instead of the ordinary arrangements of tubes employed in marine boilers. The results of a series of experiments made with marine boilers of this construction show a very considerable economy in the quantity of fuel required, and also the evaporation of a given quantity of water in a given time. This boiler occupies the same space, and is externally of the same form, as the ordinary tubular boiler.

On the Construction of the Lifeboat. By Professor MACDONALD.

Instead of the common form of the boat, with a sharp keel, the author suggested the more ample and expanded form of the head of the whale, but rising high out of the water at the bow, having bluff sides, but ending in a long clean run aft, narrowing towards the stern, where the moving paddle-wheels or Archimedean screw should be placed.

On an Improved Paddle-wheel. By Professor MACDONALD.

On Iron Floating Forts, Iron Harbours, and other Floating Structures; and on Daft's Method of Construction of Iron Fabrics. By S. J. MACKIE.

On the Theory of Diagrams of Forces as applied to Roofs and Bridges. By J. CLERK MAXWELL, *F.R.SS. L. & E.*

A roof is made up of a series of vertical frames. A diagram of forces is a figure consisting of straight lines, which represent, both in magnitude and direction, the tensions and pressures in the different pieces between the joints of the frame. The pieces of the frame and the weights acting on it are denoted by capital letters, and the corresponding lines of the diagram by small letters. The diagram is constructed by the following rule, which is sufficient for the purpose:—The frame, including the vertical lines representing the weights, and the diagrams of forces, are reciprocal figures, such that every line in the one is parallel to the corresponding line in the other, and every set of lines which meet in a point in the one figure form a closed figure in the other. It follows from this that the weights, which are all vertical forces, are represented by the parts of one vertical line. The first extension of the principle of the diagram of forces was made by Dr. Rankine in his 'Applied Mechanics.' The theory was generalized by the author in the Philosophical Magazine in April 1864. In the present paper it is shown to be connected with the theory of reciprocal polars in solid geometry, and rules for the construction of diagrams are given. The advantage of the method is that its construction requires only a parallel ruler, and that every force is represented to the eye at once by a separate line, which may be measured with sufficient accuracy for all purposes with less trouble than the forces can be found by calculation. It also affords security against error, as, if any mistake is made, the diagram cannot be completed.

On Covered Life-Boats. By GEORGE MAW, *F.S.A., F.G.S., &c.*

In advocating the employment of closely-covered boats for shipwreck service from vessels at sea, the author pointed out the different requirements from those engaged in coast service. In rescuing from the land the crews of coast-wrecked vessels, the power of navigation and locomotion was of paramount necessity, whilst in the case of vessels foundering at sea, the means of locomotion was altogether of secondary importance to such qualities as would provide for the certainty of floatation. To ensure this, the author proposed a light boat-shaped iron caisson, perfectly covered, except a man-hole for access, which would be water-tight when closed, and two openings for ventilation. A self-acting valvular arrangement was described, by which water would be perfectly excluded during the occasional breaking of a wave, whilst allowing a free passage of air when not submerged.

On a new Mode of constructing the Surface of Streets and Thoroughfares. By JOSEPH MITCHELL, *C.E., F.R.S.E.*

On the Use of Moveable Seats for Slide-Valves. By JAMES R. NAPIER, *F.R.S., Marine Engineer, and* W. J. MACQUORN RANKINE, *C.E., LL.D., F.R.S.*

The great practical convenience of the slide-valve and link-motion as means of varying the rate of expansion in steam-engines is well known. An objection to their use, however, arises from the fact, that the points of admission, cut-off,

release, and compression are related to each other in such a manner that, in designing a slide-valve motion, the fixing of any three of those points for a given position of the link fixes the fourth point also. For example, suppose that in a certain position of the link, the positions of the eccentrics and the lap or cover at the eduction-edge of the cylinder-port are so adjusted as to give a certain rate of expansion: then the only element remaining capable of adjustment is the cover at the eduction-edge of the port; and that element, when it is fixed, fixes at once the release and the compression; and it often happens that the best positions of the points of release and of compression are inconsistent with each other; so that a compromise has to be made. That objection, in some examples of slide-valve motions, has been overcome by the use of double-slides; but in all the double slide-valve motions hitherto introduced, there exists the defect of complexity in construction and working; for in addition to the ordinary handle of the link-motion, a second handle has to be used in varying the rate of expansion. The authors of this paper propose to accomplish the same result in a very simple way, by giving a small sliding motion to that part of the valve-seat which contains the induction-edges of the cylinder-ports, so as alternately to contract and enlarge those ports at each stroke of the engine. The only mechanism required, in addition to the ordinary slide-valve gear, consists in the moveable seat, with a rod and a third eccentric to give it motion: the rate of expansion is varied, when required, by shifting the link in the ordinary way by the use of the ordinary handle alone; yet the effect is the same as if the admission and the exhaust of the steam were regulated by two different slide-valves, each with its own link-motion and pair of eccentrics. Hence, in designing the valve-motion, the points of release and compression can be adjusted to the best positions, independently of the points of admission and cut-off. The authors consider that the moveable seat which they propose ought to be used together with a kind of slide-valve on which the pressure of the steam is balanced, such as that introduced by Mr. Thomas Adams, in order that the different rates of travel of the slide-valve over the fixed and moveable parts of the valve-seat may not produce unequal wear.

On the Consumption of Fuel. By William Paterson.

On some of the Difficulties the Scientific Engineer meets with in Practice. By W. W. Urquhart.

APPENDIX.

The Relation of the Upper and Lower Crags in Norfolk. By John E. Taylor, *Hon. Sec. Norwich Geol. Soc.*

The object of this paper was to prove that the present classification of shells in the Norwich Crag is imperfect on account of an upper bed being included in the Crag. The mean percentage of the shells from the two crags makes the relation of the Red and Norwich Crags very dissimilar, whereas there is really a near connexion between them. By separating the shells of the upper bed, the underlying Norwich Crag approaches the Red, whilst the upper bed itself forms a graduating link between the three Crags and the overlying Drift beds.

After giving the established percentages of recent and extinct shells in the three Crags, as well as the proportion of arctic shells found in them, the author mentioned several places in Norfolk where the Upper Crag may be seen overlying the Norwich Crag, as at Coltishall, Horstead, Trowse, Thorpe, Whitlingham, and Bramerton. The height of the upper bed ranges above the lower from 3 to 15 feet. It is marked by the total absence of freshwater shells, by the paucity of littoral species, and by the abundance of deeper sea-shells. It is also distinguished by the greater abundance of arctic species, as at Bramerton and Thorpe, where several species of *Astarte, Cyprina islandica, Cardium grœnlandicum, Lucina borealis*, and others abound.

The author also showed that the shells of the Red and Norwich Crags separated them into distinct beds, whilst the same method would also separate the Upper from the Lower Crag in Norfolk. He therefore contended for the existence of *four* Crags instead of the present classification of them into *three*. This arrangement established a complete and beautiful sequence between the oldest Coralline Crag and the latest Drift deposits.

On the Internal Heat of the Earth. *By* Dr. Julius Schvarcz, *F.G.S.*

The author reviewed the evidence upon which is founded the doctrine of central heat as applied to the earth. It is based on three arguments:—*one*, gathered from volcanic phenomena—phenomena which may be explained by the chemical and electro-chemical schools of geologists at least as satisfactorily as by the supporters of central fire; the *second* argument is deduced from the nebular hypothesis, an hypothesis having now-a-days no other foundation than what is involved in it from the central-fire hypothesis; and the third is deduced from the supposed uniform increase of temperature down to the centre of our planet, in every part of the earth,—an argument which, again, is a mere hypothesis.

Having carefully studied the literature of the subject, Dr. Schvarcz criticised the observations upon which the hypothesis of central fire is supported, and showed how imperfect and conflicting is the evidence to prove that the increase of underground temperature is really general and uniform.

Before generalizing, we must accumulate a greater number of facts, precisely recorded, than are at present at command; and he therefore urged geologists to combine all their efforts in order to multiply geothermometrical observations, especially in countries now unexplored.

He was of opinion that solar impressions, in all the climates on our earth's surface, taken collectively, and local reservoirs of lava, not exceeding considerably the depth of thirty-five geographical miles, and manifesting themselves through volcanic cones from local processes of oxidation, must be taken for those secondary causes which remain indispensable elements of any ætiology of underground temperatures, even for theories to come. Electricity, as connected with cosmical magnetism and planetary rotation, may have been an important agent, besides the secondary causes just alluded to.

Nouvelle comparaison des membres pelviens et thoraciques chez l'Homme, les Mammifères, les Oiseaux et les Reptiles, déduite de la torsion de l'humérus. *Par* Charles Martins.

Vicq-d'Azyr est le premier qui ait attaqué résolument et discuté sérieusement le problème du parallèle des extrémités chez l'homme et chez les quadrupèdes. Son mémoire parut en 1778. Mettant un squelette du bras de l'homme en tournant l'olécrane en avant, à côté d'un membre inférieur du même côté, il vit que les deux axes du col du fémur et du col de l'humérus n'étaient pas parallèles, et eut la malheureuse idée pour rétablir ce parallélisme de comparer le membre supérieur droit au membre inférieur gauche et *vice versâ*; mais alors le pouce de la main est en dehors, et le gros orteil du pied, qui est son analogue, en dedans; ce qui viole la loi de symétrie. Du reste Vicq-d'Azyr, comme plus tard Goethe, Meckel, et Barclay, assimile le radius au tibia et le cubitus au péroné, sans expliquer pourquoi la rotule analogue de l'olécrane est fixée au tibia, tandis qu'elle devrait faire partie du péroné.

En 1832 Bourgery, pour résoudre cette difficulté, prétendait que la partie supérieure du tibia avec la rotule représentait le cubitus surmonté de l'olécrane, tandis que la partie inférieure du même os correspondait au radius; de même selon lui la partie supérieure du péroné était le radius, sa partie inférieure le cubitus. Cette hypothèse, connue en France sous le nom d'*hypothèse du croisement*, fut adoptée en 1843 par M. Cruveilhier, qui la formula nettement; mais dans cette manière de voir, l'avant-bras étant en pronation, le cubitus et le radius se *croisent* tandis que le péroné et le tibia sont parallèles entre eux. De plus, il est contraire à toutes les lois connues des coalescences de supposer qu'un os long peut être formé par la soudure bout à bout des moitiés de deux os longs différents.

En 1838 M. Flourens compare le membre supérieur, l'avant-bras étant en pro-

nation, avec le membre inférieur du même côté : mais alors l'olécrane est en arrière, tandis que la rotule est en avant; l'avant-bras se fléchit en avant, tandis que la jambe se fléchit en arrière. Les zoologistes qui adopteraient cette explication compareraient sans le savoir, non pas le membre thoracique de l'homme à son membre pelvien, mais le membre thoracique de l'homme au membre thoracique des quadrupèdes, chez lesquels l'avant-bras est en effet dans une pronation fixe et permanente; aussi cette explication n'est-elle pas plus satisfaisante que les autres. Voici celle que je propose.

Explication de l'auteur.—L'humérus, chez l'Homme et les Mammifères terrestres ou aquatiques, est un os tordu sur son axe de 180 degrés, ou d'une demi-circonférence : le fémur est un os droit sans torsion. L'humérus étant un fémur tordu, si l'on veut comparer ces deux os il faut avant tout *détordre* l'humérus; le résultat de cette opération est de placer l'épitrochlée en dehors et l'épicondyle en dedans. Cela fait, la comparaison des membres n'offre plus aucune difficulté : en effet le col de l'humérus est dirigé en dedans comme celui du fémur. La partie convexe ou tricipitale de l'os du bras se trouve en avant comme la partie convexe ou tricipitale de l'os de la cuisse. Les deux os sont donc semblables; leurs condyles articulaires se contournent en arrière; l'olécrane est en avant, comme la rotule; de plus elle est attachée à la portion antérieure et externe de la tête du tibia, qui représente (comme je le prouverai plus bas) la portion olécranienne de la tête du cubitus, qui s'est soudée et confondue avec celle du radius. Pour se convaincre de la réalité de la torsion de l'humérus, il suffit de suivre sur un humérus d'homme ou de quadrupède la ligne âpre qui part de l'épicondyle, se dirige obliquement vers la face postérieure, la contourne en longeant la gouttière de torsion du nerf radial, et vient aboutir à la partie la plus marquée du col au-dessous de la tête de l'humérus. Cette torsion a été remarquée par la plupart des anthropotomistes—Bertin, Locat, Winslow, Sabatier, Soemmering, Bichat, Boyer, Barclay, Meckel, J. Cloquet, H. Cloquet, Lauth, O. Ward, Blandin, Estor, Cruveilhier, Holmes-Coote, Jamin, Sappey, Henle, G. M. Humphry, et L. Holden. C'est la torsion qui transforme le sens de la flexion, puisque l'avant-bras se fléchit en avant, tandis que le jambe se fléchit en arrière. Mr. Holmes-Coote est, à ma connaissance, le seul anatomiste qui ait vu cette conséquence de la torsion. Mr. Maclise dans son article *Skeleton*, dans Todd's 'Cyclopædia,' a compris toute l'importance de la vue de Mr. Holmes-Coote pour la comparaison des membres. Mais tous deux se sont arrêtés à cette remarque fondamentale; ils n'ont point songé à mesurer l'angle de torsion de l'humérus dans les différentes classes des Vertébrés.

De la torsion de l'humérus dans l'Homme et les Mammifères terrestres ou aquatiques.—Elle est toujours de 180°; mais les rapports des axes du col et de la trochlée ne sont pas les mêmes dans toute la série. Chez l'Homme et les Singes anthropomorphes (Orang, Chimpansé, Gorille et Gibbon) les axes du col du fémur et de l'humérus sont dirigés tous deux vers la colonne vertébrale, savoir *de dehors en dedans* et de bas en haut. Cette direction des axes est la condition mécanique des mouvemens de circumduction du bras, qui décrit un cône autour de cet axe idéal. Dans les quadrupèdes terrestres et amphibies, l'axe du col de l'humérus est dirigé *d'avant en arrière*. La conséquence de cette dernière disposition c'est que dans les quadrupèdes le membre antérieur se meut dans un plan et n'exécute plus les mouvemens de circumduction qui caractérisent l'Homme et les Singes anthropomorphes.

De la torsion de l'humérus dans les Cheiroptères, les Oiseaux et les Reptiles.—Elle est de 90° seulement. L'axe du col de l'humérus est dirigé comme chez l'homme, mais le corps de l'humérus n'étant tordu que de 90°, la trochlée est tournée *en dehors* et non en avant : aussi la flexion de l'avant-bras sur le bras se fait-elle *en dehors* dans un plan perpendiculaire au plan vertébro-sternal. Une Chauve-souris, un oiseau déploient leurs ailes *en dehors*, un reptile étend son avant-bras perpendiculairement à l'axe de son corps. La torsion de 90° est donc une des conditions ostéologiques du vol et de la reptation. Dans les Cheiroptères c'est dans les grandes Roussettes (*Pteropus vulgaris*, *P. Edwardsii*, *P. Keraudrenii*, et *P. poliocephalus*) qu'il faut étudier la torsion de l'humérus. Dans les Oiseaux la torsion de 90° se voit le mieux sur les humérus des grands Rapaces tels que les Condors, les Vautours, les Aigles, les Albatros, et sur les grands Gallinacés. Dans les Reptiles je citerai les Crocodiles, les Caïmans, les Varans, les Grammatophores, les *Uromastix* et le *Salvator*

Merianæ. Sur le Caméléon, au contraire, l'humérus est tordu de 180°; car le Caméléon est un reptile qui ne rampe pas; il marche, comme un quadrumane, en fléchissant son avant-bras en avant. Son ventre ni sa queue ne traînent par terre. Comme les Singes, il saisit les branches avec ses quatre mains, et enroule sa queue prenante autour des branches qui lui servent de support. Dans les Chéloniens la torsion n'est visible que sur les grandes Tortues terrestres et fluviatiles et dans les Batraciens, sur les Crapauds et les grosses Grenouilles. Cette torsion de l'humérus de 90°, commune aux Reptiles et aux Oiseaux, est un trait de plus à ajouter aux nombreuses ressemblances organiques qui rapprochent ces deux classes d'animaux.

Origine de la Torsion.—Je dois aborder maintenant une question d'autant plus délicate qu'elle est du domaine de la métaphysique, et touche aux lois les plus intimes du développement des êtres organisés. Quand on examine des squelettes de fœtus humains depuis deux mois jusqu'à neuf, le corps de l'humérus se présente sous la forme d'une palette aplatie et identique, sauf la grandeur, à celle du fémur. On n'y remarque pas la plus légère trace de torsion. Cette torsion n'est même visible que sur un enfant d'un an, et ce n'est qu'à deux ans qu'elle est parfaitement caractérisée. Cependant du jour où les membres se montrent sur le fœtus *la torsion existe*, puisque la flexion du bras se fait *en avant*. La torsion de l'humérus n'est donc point une torsion mécanique qui s'opère à une certaine epoque de la vie, c'est une torsion *virtuelle* qui ne s'est jamais opérée mécaniquement; mais cette torsion virtuelle a eu toutes les conséquences d'une torsion réelle. Tout dans le bras est disposé comme si elle s'était physiquement effectuée: les muscles, les artères, les nerfs ont suivi le mouvement de rotation de l'extrémité inférieure de l'humérus. Les autres dissemblances entre le bras et la cuisse sont de simples conséquences de cette torsion. J'ose espérer que le lecteur partagera cette conviction; car je démontrerai que la disposition de toutes les parties molles du membre thoracique comparée à celle des parties correspondantes du membre abdominal ne s'explique que par la torsion de l'humérus: il est le *seul os long* dont le corps soit ainsi contourné en hélice: en lui imprimant cette forme la nature nous dévoile le procédé simple et rationnel par lequel le sens de la flexion devient antérieur ou externe de postérieur qu'il était.

Nous trouvons dans l'histoire naturelle d'autres exemples de ces effets virtuels. La queue unique des poissons doubles figurés par M. Coste n'a qu'une colonne vertébrale: virtuellement cependant les deux colonnes existent dans la queue du poisson double; mais la colonne centrale ne s'est pas développée. Dans les végétaux, mêmes faits; dans toutes les Labiées la lèvre supérieure de la corolle est à un ou deux lobes, et elle contient les étamines, qui sont *convexes* en dessus. Mais dans la tribu des Ocimoïdées (*Ocimum*, *Orthosiphon*, *Plectranthus*, *Coleus*, &c.) la lèvre supérieure est à 4 lobes; l'inférieure, à un seul, correspond aux étamines, qui sont *concaves* en dessus. Il est admis par tous les botanistes que dans cette tribu la corolle est renversée; et cependant jamais aucun d'eux n'a vu ce renversement s'opérer: la fleur naît renversée, comme l'humérus naît tordu; je m'en suis assuré sur des boutons de fleurs de *l'Ocimum carnosum*, qui n'avaient pas plus d'un millimètre de long. Dans toute cette tribu de végétaux il y a donc un renversement virtuel analogue à la torsion virtuelle de l'humérus des vertébrés.

Composition de la tête fémorale du tibia.—Nous avons à démontrer actuellement que le chapiteau du tibia chez l'Homme et la plupart des Mammifères est formé par la coalescence, la soudure des têtes du cubitus et du radius réunis. Tous les anatomistes ont été frappés de la disproportion du tibia et du péroné; le premier formant une colonne massive, terminée supérieurement par un énorme chapiteau; le second, long, grèle, aminci, évidemment atrophié et souvent réduit, comme chez le cheval et les ruminans, à une simple apophyse styloïde. Il semble qu'en se transformant en tibia le radius se soit développé aux dépens du cubitus, ou plutôt l'ait incorporé à lui. C'est ce qui a lieu en réalité, puisque le chapiteau du tibia est formé par la coalescence des têtes du cubitus et du radius. En effet on remarque sur le tibia deux faces articulaires comme celles du cubitus et du radius. L'épine qui sépare les deux surfaces articulaires ne correspond pas, comme on le dit généralement, à la crête qui va du sommet de l'olécrane à l'apophyse coronoïde, mais à l'intervalle qui sépare la tête du cubitus

de la cupule articulaire du radius. Si l'on place à côté l'un de l'autre un coude et un genou de squelette humain, et qu'on les regarde de profil, il est impossible de méconnaître la ressemblance prodigieuse de la crête antérioure du tibia à partir de l'insertion du ligament rotulien jusqu'au dessous du tiers supérieur de l'os, avec la crête postérieure du cubitus, qui part de l'olécrane et se prolonge également jusqu'au dessous du tiers supérieur de l'os. Toutes deux sont tranchantes, toutes deux offrent à leur partie moyenne une incurvation dans le même sens. Qu'on admette donc une coalescence des deux têtes du radius et du cubitus, ou qu'on dise simplement que le radius s'est développé aux dépens du cubitus pour former la tête du tibia, toujours est-il qu'on ne saurait nier le *caractère cubital* de la portion antérieure du tiers supérieur du tibia. A partir de l'incurvation de la crête, la coalescence cesse, et la partie inférieure du péroné correspond à celle du cubitus seul, tandis que la partie inférieure du tibia représente uniquement celle du radius.

L'analogie de la rotule et de l'olécrane a été reconnue par Winslow, Vicq-d'Azyr, Sabatier, Soemmering, Boyer, Meckel, Gerdy, J. Cloquet, Bourgery, Blandin, O. Ward, Cruveilhier, Henle, G. M. Humphry, &c. L'anatomie comparée confirme cette analogie. Dans les *Pteropus*, la Chauve-souris vampire, et le Pingouin, l'olécrane est separé du cubitus comme la rotule du tibia. Dans les Reptiles et les Oiseaux les deux os manquent à la fois.

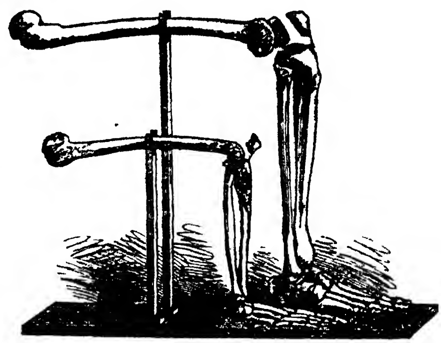
Une confirmation de ce que nous avons dit sur la composition du chapiteau du tibia se trouve dans les Marsupiaux, tels que *Phascolomys*, *Phalangista*, *Dasyurus* et Opossum. Dans le *Phascolomys wombat* le tibia et le péroné sont de même grosseur, le péroné s'articule avec le fémur comme le cubitus avec l'humérus, et il porte une rotule dont la forme est la même que celle de l'olécrane de l'animal. La crête du tibia manque. Dans cet animal le péroné avec sa rotule représente exactement le cubitus, et le tibia correspond au radius seul. On trouve une conformation analogue dans le *Dasyurus macrourus*, le *Didelphys Azaræ*, *Phalangista vulpina*, *P. Cookii* et autres. Dans l'Ornithorhynque le tibia et le péroné sont surmontés, le premier d'une rotule, le second d'une apophyse olécranienne. L'appareil rotulien du genou étant double, l'appareil olécranien du coude l'est également, et l'olécrane est bifurqué et se termine par deux crochets. En résumé, dans les Phascolômes, les Phalangers, les Dasyures et les Opossum, où le tibia ne représente que le radius, le péroné, au contraire, le cubitus tout entier, la rotule s'insère au péroné comme l'olécrane est uni au cubitus.

Si l'on compare le coude et le genou dans les Mammifères ordinaires, et en particulier dans les Insectivores, les Rongeurs, les Ruminans, et les Solipèdes, on arrive aux conclusions suivantes:—1. La tête du cubitus, c'est-à-dire l'olécrane, et la crête qui lui fait suite dans le tiers supérieur de l'os, existent dans tous les Mammifères terrestres et amphibies. Les parties correspondantes du genou, savoir, la rotule et la crête antérieure de l'os jusqu'au dessous de son tiers supérieure, sont également constantes. 2. Au contraire, le corps du cubitus, ou plus exactement, cet os, moins l'olécrane et la crête qui lui fait suite, n'est pas constant, il s'atrophie ou se confond avec le radius. Le péroné, qui correspond *précisément* à cette portion du corps cubital, non seulement s'atrophie et diminue de longueur en s'amincissant, mais disparaît même complétement dans le Dromadaire.

La comparaison du pied avec la main par Vicq-d'Azyr a été admise par tous les anatomistes; il en est de même de l'épaule et du bassin; mais il ne faut pas, comme lui, comparer l'iléum droit à l'épaule gauche: il faut placer un petit miroir sous l'angle inférieure de l'omoplate d'un squelette: en regardant l'image de cette omoplate dans le miroir, on reconnaît, pour ainsi dire, l'iléum placé au dessous, et l'on constate que la clavicule correspond à la branche horizontale du pubis, l'apophyse coracoïde à l'ischion, le bord spinal de l'omoplate à la crête de l'os des iles, l'angle inférieur de l'omoplate à l'epine antérieure et supérieure de l'ileum, la fosse susépineuse à la fosse iliaque externe, la crête de l'omoplate et l'acromion à la crête qui sépare le petit du moyen fessier. Dans l'Ornithorynque et l'*Echidna* le bassin et l'épaule se ressemblent complétement.

L'auteur a presenté à la Section une préparation ostéologique qui réalise ses idées. L'humérus est détordu et le radius transformé en tibia par l'addition de la partie olécranienne du cubitus: l'olécrane, séparé par la scie, représente la rotule; et le corps du cubitus, aminci dans sons tiers supérieur, simule parfaitement le péroné.

Une photographie de cette préparation a été distribuée aux assistans. La gravure suivante en est la reproduction.



Comparaison des muscles du membre pelvien et du membre thoracique chez l'Homme.—Chercher à retrouver tous les muscles de la cuisse et de la jambe dans le bras et dans l'avant-bras est évidemment chose impossible; leur nombre n'est pas le même. Mais il est d'abord certains muscles qui sont *homologues*, c'est-à-dire, que leurs deux points d'attache sont les mêmes. A la cuisse et au bras on remarque: le *supraspinatus* et le *glutæus medius*; *glutæus minor* et *infraspinatus*; *iliacus internus* et *subscapularis*; *pars longa bicipitis femoris* et *coraco-brachialis*; les deux *triceps*; *pars brevior bicipitis femoris* et *brachialis internus*. A la jambe et à l'avant-bras: *popliteus* et *pronator teres*; *gastrocnemius externus* et *ulnaris internus*; *plantaris* et *palmaris longus*; *peroneus brevis et ulnaris externus*. Au pied et à la main *abductor hallucis et adductor pollicis manus*; *musculi lumbricales et interossei pedis et manus*.

Les muscles analogues sont ceux où l'une des insertions est homologue, tandis que l'autre ne l'est pas. Ex. *gluteus major* et *deltoideus*; *pectineus* et *pars clavicularis pectoralis majoris*, &c. Enfin il est des muscles qui sont sans analogues évidents aux extrémités pelviennes et thoraciques. Ex. Au bras, *teres major* et *latissimus dorsi*; à la cuisse, *M. pyriformis*, *obturatores*, *quadratus femoris*, *sartorius*, &c. A la jambe, *M. peroneus longus*. A l'avant-bras, *M. pronator quadratus*, *radialis externus longior*, *supinator brevis*, &c.

La position des muscles homologues et analogues est celle qui résulte de la torsion de 180° de l'humérus. Les muscles qui sont en arrière au bras sont en avant à la cuisse, Ex. Les *triceps*; *pronator teres brachii* et *popliteus*. Ceux qui sont en dehors au bras sont en dedans à la cuisse, Ex. *gastrocnemius externus* et *ulnaris internus*.

Comparaison des artères et des nerfs du membre pelvien et du membre thoracique chez l'Homme.—A la partie supérieure du bras l'artère brachiale est placée, comme la crurale, en dedans et en avant de la tête de l'humérus; mais la crurale contourne le fémur vers le quart inférieur de l'os, et passe *derrière* lui pour se placer entre ses condyles, où elle prend le nom de poplitée. L'humérus etant un *fémur tordu*, son mouvement de rotation a eu pour effet de ramener les condyles en avant et d'entraîner l'artère, qui, conservant les mêmes relations avec les parties osseuses, se trouve placée *en avant* dans le pli du bras. La radiale correspond à la tibiale postérieure; la cubitale à la péronière; les interosseuses de la jambe à celles du bras.

Comme les systèmes musculaires et artériels, le système nerveux démontre la réalité de la torsion de l'humérus. Un des troncs nerveux, le sciatique, à la cuisse le médian, et le cubital au bras, sont dans le plan de la flexion. Les deux autres nerfs, le crural antérieur, à la cuisse, le radial, au bras, dans le plan de l'éxtension. Mais à la cuisse tous les nerfs principaux restent dans le plan où ils se trouvaient a leur origine. Au bras, au contraire, le median et le cubital obéissent à cette loi, tandis que le nerf radial quitte le plan interne dès le quart supérieur du membre, se dirige en arrière, contourne l'os en hélice, suivant sa ligne de torsion, y laisse l'empreinte de son passage et ressort sur la face externe de l'os pour se distribuer aux muscles qui s'y insèrent. Tous les anatomistes ont été frappés de la singularité de ce trajet, qui ne s'explique ni par des conditions de symétrie, ni par des adaptations fonctionnelles; car pour gagner les muscles de la partie externe du bras le chemin le plus court était de passer entre le biceps et le brachial antérieur. Seule, la torsion de l'humérus rend compte des différences qui existent entre les systèmes nerveux du bras et de la cuisse. Je suis parvenu à réaliser mécaniquement la transformation de l'appareil nerveux de la cuisse en appareil nerveux du bras. Voici comment. Je fixe le chef d'un cordon noir derrière un fémur du côté droit

entre les deux trochanteurs. Ce cordon représente le tronc sciatique. Je fixe son autre extrémité, qui figure le nerf sciatique poplité interne, entre les deux condyles fémoraux. Du milieu de ce cordon en part un second, qui s'attache au condyle externe ou péronéal et simule le nerf poplité externe. Un autre cordon noir, attaché en dedans du condyle interne ou tibial, représente le nerf crural. Je place ensuite ce fémur sur une table. Sa convexité est tournée en haut; le nerf sciatique et ses deux branches sont derrière l'os, dans leur position naturelle. Un aide tient lâchement l'extrémité libre du cordon, qui représente le nerf crural, au-dessus de la tête du fémur. Les choses ainsi disposées, je fais tourner vers moi le fémur et le cordon représentant le nerf sciatique, de 180°. Le sciatique, suivant le mouvement de rotation, se trouve placé devant l'os au lieu de rester derrière, et l'extrémité inférieure du nerf crural, entraînée par le mouvement du condyle interne devenu externe, contourne le corps du fémur comme le nerf radial contourne le corps de l'humérus. Par ce mouvement de rotation de 180° j'ai simulé la torsion qui transforme le fémur en humérus, et par cela seul j'ai transformé le système nerveux de la cuisse en système nerveux du bras.

La comparaison des membres déduite de la torsion de l'humérus a été déjà admise par Hugh Falconer, Cruveilhier, Valentin, A. Pictet, Ch. Robin, Ch. Rouget, Brown-Sequard, Beaunis et Bouchard, &c. L'auteur se propose de répondre bientôt à quelques objections qu'elle a soulevées.

Sur les Racines aérifères ou Vessies natatoires, la synonymie et la distribution géographique de quelques espèces aquatiques du genre Jussiæa. *Par* Charles Martins, *Professeur et Directeur du Jardin des Plantes de Montpellier.*

Le genre *Jussiæa* de la Famille des Onagraires se compose actuellement d'environ 80 espèces, les unes terrestres, les autres aquatiques, végétant dans les eaux douces et tranquilles de l'Asie, de l'Afrique, de l'Amérique et de l'Australie. Rheede le premier ('Hortus malabaricus,' t. ii. p. 99 et tab. 51; 1679) figura sur les rameaux du *Jussiæa repens* du Malabar des racines blanches, spongieuses et flottantes dans l'eau. Ces organes furent revus par Humboldt et Bonpland sur le *J. natans* de la Nouvelle Grenade, par John Sims sur le *J. grandiflora* au Jardin de Kew, et par Delile sur la même plante, comme le prouve une note manuscrite de sa main dans l'herbier du Jardin de Montpellier. Plus tard de Martius donnait le nom de *J. helminthorhiza* à une plante de Bahia, et Hasskarl décrivit avec plus de détail les racines du *J. repens* de Java. Ayant reçu des graines du *Jussiæa repens* découvert près de Bone, en Algérie, et la plante végétant très-bien dans le Jardin, je résolus de l'étudier simultanément avec le *J. grandiflora*, qui non seulement se maintient dans un canal de l'école botanique depuis 1823, mais encore s'est naturalisé depuis 1830, dans la petite rivière du Lez près Montpellier et les canaux d'irrigation qui en dependent.

Racines aérifères des Jussiæa repens *et* J. grandiflora.—Quand on étudie ces deux plantes on trouve qu'elles ont quatre sortes de racines naissant sur les renflemens des rameaux immergés qui portent également des feuilles et des fleurs. 1°. des racines filiformes flottantes, non ramifiées, situées vers l'éxtrémité des rameaux. 2°. des racines rameuses ou plutôt pectiniformes également flottantes. 3°. Des racines également pectiniformes mais dont l'axe est devenu plus épais, blanchâtre et spongieux; celles-ci flottantes ou s'enfonçant dans la vase. 4°. Enfin des racines d'un aspect différent complétement de celui des précédentes, simples, cylindriques, ou coniques, molles, spongieuses, blanchâtres ou rosées, toujours flottantes et remplies d'une grande quantité d'air, ce sont les *racines aérifères*, véritables vessies natatoires de la plante qu'elles soutiennent à la surface de l'eau. L'examen microscopique prouve qu'elles se composent d'un faisceau vasculaire central, puis d'un tissu cellulaire à grandes mailles lacunaires remplies d'air, qui sont en contact avec l'eau sans l'interposition d'une couche épidermique. Cette structure, comparée à celle d'une racine ordinaire ramifiée, montre que la racine aérifère n'est qu'une modification de la racine absorbante. Celle-ci se compose en effet: 1. d'un faisceau vasculaire central, identique à celui de la racine spongieuse; 2. d'un tissu cellulaire formé de rangées de cellules prismatiques juxtaposées au centre mais séparées vers la circonférence par des lacunes intercellulaires remplies

de gaz, et d'autant plus grandes qu'on les observe plus près de la périphérie; 3. d'une couche épidermique formée de plusieurs rangées de cellules allongées. La transformation du tissu cellulaire en tissu lacunaire produit la distention et le raccourcissement de la racine, amène la destruction de l'épiderme, détermine l'avortement presque constant des ramifications latérales, et transforme un organe absorbant en une véritable vessie natatoire qui soutient les stolons du végétal à la surface de l'eau. Sur quelques individus le tissu spongieux aérifère se développe également sur la tige et fait saillie à travers l'épiderme déchiré.

M. Moitessier, Agrégé de chimie à l'Ecole de Médecine de Montpellier, s'est assuré par 15 analyses très-concordantes, faites chacune sur 15 a 30 centimètres cubes d'air, que cet air se compose en moyenne de

Azote	87·0
Oxygène	13·0
	100·0

La composition de l'air dissous dans l'eau était de 31·3 pour cent d'oxygène dans l'eau courante, et de 16·7 pour cent quand l'eau ne se renouvelait pas, sans que la composition de celui des racines fût affectée par ces différences. Ainsi donc dans les végétaux aquatiques divers organes—les feuilles dans les *Utricularia* et l'*Aldrovandia vesiculosa*, les pétioles dans le *Trapa natans* et le *Pontederia crassipes*, les racines dans les *Jussiæa* aquatiques jouent le rôle de vessies natatoires. Il en est de même dans les animaux où la vessie natatoire des Poissons est l'analogue du poumon des Mammifères, tandis que dans les Nautiles ce sont les chambres de la coquille, dans certains Siphonophores des vésicules aériennes ou des boucliers aérifères, comme dans les Vélelles, qui soutiennent l'animal à la surface ou dans une zone déterminée au-dessous de la surface de l'eau. Ainsi dans le règne animal comme dans le règne végétal les mêmes fonctions sont remplies par des organes différens, qui n'ont jamais une destination unique et determinée d'avance.

Synonymie et distribution géographique du Jussiæa repens.—Après avoir cultivé pendant cinq ans cette espèce dans les conditions les plus variées de sécheresse et d'humidité, j'ai pu constater combien la forme, les dimensions, la pubescence de ses feuilles, la grandeur de ses fleurs, le port enfin tout entier de la plante étaient sujets à varier. Bien familiarisé avec ces variations d'un même type spécifique, j'ai abordé les herbiers et me suis assuré que le *Jussiæa repens*, décrit par Linnée en 1747 dans sa 'Flora Zeylanica', avait reçu dix-huit noms, en y comprenant le nom indien de *Nir Carambu*, sous lequel Rheede l'a decrit le premier en 1679. Ces noms sont: *Caryophyllus spurius malabaricus pentapetalus aquatilis repens*, Ray; *Lysimachia indica non papposa repens flore pentapetalo, fructu caryophylloïde*, Commelin; *Cubospermum palustre*, Lour.; *Jussiæa repens*, L.; *J. adscendens*, L.; *J. diffusa*, Forsk.; *J. grandiflora*, Mich.; *J. peploides*, H., B., K.; *J. polygonoïdes*, H., B., K.; *J. fluvialis*, Blume; *Jussiera montevidensis*, Spr.; *J. ramulosa*, DC.; *J. Swartziana*, DC.; *J. stolonifera*, Guill. et Per.; *Jussieua alternifolia*, E. Mey.; *Jussiæa australasica*, Ferd. Mull.; *J. fluitans*, Hochst.

La plupart de ces synonymes correspondent à la forme aquatique du *Jussiæa repens* végétant dans des eaux tranquilles. La forme *J. grandiflora* est celle des eaux courantes; et les formes *J. diffusa* et surtout *J. stolonifera* celles des terrains d'abord humides puis desséchés. L'auteur fait passer sous les yeux des assistans de nombreux échantillons du *Jussiæa repens* cultivés dans différentes conditions de sécheresse et d'humidité, et d'autres provenant de divers pays.

La synonymie si nombreuse de cette plante n'a rien de surprenant quand on sait combien elle est polymorphe et combien son aire d'extension est considérable. On la trouve dans les quatre parties du monde; car elle occupe une large bande faisant le tour du globe et dont les deux bords extrêmes, parallèles à l'equateur et situés l'un dans l'hémisphère nord, l'autre dans l'hémisphère sud, sont eloignés chacun de 35 degrés latitudinaux de la ligne équinoxiale.

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CONTENTS:—Prof. Langberg, on the Specific Gravity of Sulphuric Acid at different degrees of dilution, and on the relation which exists between the Development of Heat and the coincident contraction of Volume in Sulphuric Acid when mixed with Water;—R. Hunt, Researches on the Influence of the Solar Rays on the Growth of Plants;—R. Mallet, on the Facts of Earthquake Phenomena;—Prof. Nilsson, on the Primitive Inhabitants of Scandinavia;—W. Hopkins, Report on the Geological Theories of Elevation and Earthquakes;—Dr. W. B. Carpenter, Report on the Microscopic Structure of Shells;—Rev. W. Whewell and Sir James C. Ross, Report upon the Recommendation of an Expedition for the purpose of completing our knowledge of the Tides;—Dr. Schunck, on Colouring Matters;—Seventh Report of the Committee on the Vitality of Seeds;—J. Glynn, on the Turbine or Horizontal Water-Wheel of France and Germany;—Dr R. G. Latham, on the present state and recent progress of Ethnographical Philology;—Dr. J. C. Prichard, on the various methods of Research which contribute to the Advancement of Ethnology, and of the relations of that Science to other branches of Knowledge;—Dr. C. C. J. Bunsen, on the results of the recent Egyptian researches in reference to Asiatic and African Ethnology, and the Classification of Languages;—Dr. C. Meyer, on the Importance of the Study of the Celtic Language as exhibited by the Modern Celtic Dialects still extant;—Dr. Max Muller, on the Relation of the Bengali to the Arian and Aboriginal Languages of India;—W. R. Birt, Fourth Report on Atmospheric Waves;—Prof. W. H. Dove, Temperature Tables, with Introductory Remarks by Lieut.-Col. E. Sabine;—A. Erman and H. Petersen, Third Report on the Calculation of the Gaussian Constants for 1829.

Together with the Transactions of the Sections, Sir Robert Harry Inglis's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE EIGHTEENTH MEETING, at Swansea, 1848, *Published at* 9s.

CONTENTS:—Rev. Prof. Powell, A Catalogue of Observations of Luminous Meteors;—J. Glynn on Water-pressure Engines;—R. A. Smith, on the Air and Water of Towns;—Eighth Report of Committee on the Growth and Vitality of Seeds;—W. R. Birt, Fifth Report on Atmospheric Waves;—E. Schunck, on Colouring Matters;—J. P. Budd, on the advantageous use made of the gaseous escape from the Blast Furnaces at the Ystalyfera Iron Works;—R. Hunt, Report of progress in the investigation of the Action of Carbonic Acid on the Growth of Plants allied to those of the Coal Formations;—Prof. H. W. Dove, Supplement to the Temperature Tables printed in the Report of the British Association for 1847;—Remarks by Prof. Dove on his recently constructed Maps of the Monthly Isothermal Lines of the Globe, and on some of the principal Conclusions in regard to Climatology deducible from them; with an introductory Notice by Lt.-Col. E. Sabine;—Dr. Daubeny, on the progress of the investigation on the Influence of Carbonic Acid on the Growth of Ferns;—J. Phillips, Notice of further progress in Anemometrical Researches;—Mr. Mallet's Letter to the Assistant-General Secretary;—A. Erman, Second Report on the Gaussian Constants;—Report of a Committee relative to the expediency of recommending the continuance of the Toronto Magnetical and Meteorological Observatory until December 1850.

Together with the Transactions of the Sections, the Marquis of Northampton's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE NINETEENTH MEETING, at Birmingham, 1849, *Published at* 10s.

CONTENTS:—Rev. Prof. Powell, A Catalogue of Observations of Luminous Meteors;—Earl of Rosse, Notice of Nebulæ lately observed in the Six-feet Reflector;—Prof. Daubeny, on the Influence of Carbonic Acid Gas on the health of Plants, especially of those allied to the Fossil Remains found in the Coal Formation;—Dr. Andrews, Report on the Heat of Combination;—Report of the Committee on the Registration of the Periodic Phenomena of Plants and

Animals;—Ninth Report of Committee on Experiments on the Growth and Vitality of Seeds;—F. Ronalds, Report concerning the Observatory of the British Association at Kew, from Aug. 9, 1848 to Sept. 12, 1849;—R. Mallet, Report on the Experimental Inquiry on Railway Bar Corrosion;—W. R. Birt, Report on the Discussion of the Electrical Observations at Kew.

Together with the Transactions of the Sections, the Rev. T. R. Robinson's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTIETH MEETING, at Edinburgh, 1850, *Published at* 15*s.*

Contents:—R. Mallet, First Report on the Facts of Earthquake Phenomena;—Rev. Prof. Powell, on Observations of Luminous Meteors;—Dr. T. Williams, on the Structure and History of the British Annelida;—T. C. Hunt, Results of Meteorological Observations taken at St. Michael's from the 1st of January, 1840 to the 31st of December, 1849;—R. Hunt, on the present State of our Knowledge of the Chemical Action of the Solar Radiations;—Tenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Major-Gen. Briggs, Report on the Aboriginal Tribes of India;—F. Ronalds, Report concerning the Observatory of the British Association at Kew;—E. Forbes, Report on the Investigation of British Marine Zoology by means of the Dredge;—R. MacAndrew, Notes on the Distribution and Range in depth of Mollusca and other Marine Animals, observed on the coasts of Spain, Portugal, Barbary, Malta, and Southern Italy in 1849;—Prof. Allman, on the Present State of our Knowledge of the Freshwater Polyzoa;—Registration of the Periodical Phenomena of Plants and Animals;—Suggestions to Astronomers for the Observation of the Total Eclipse of the Sun on July 28, 1851.

Together with the Transactions of the Sections, Sir David Brewster's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-FIRST MEETING, at Ipswich, 1851, *Published at* 16*s.* 6*d.*

Contents:—Rev. Prof. Powell, on Observations of Luminous Meteors;—Eleventh Report of Committee on Experiments on the Growth and Vitality of Seeds;—Dr. J. Drew, on the Climate of Southampton;—Dr. R. A. Smith, on the Air and Water of Towns: Action of Porous Strata, Water and Organic Matter;—Report of the Committee appointed to consider the probable Effects in an Economical and Physical Point of View of the Destruction of Tropical Forests;—A. Henfrey, on the Reproduction and supposed Existence of Sexual Organs in the Higher Cryptogamous Plants;—Dr. Daubeny, on the Nomenclature of Organic Compounds;—Rev. Dr. Donaldson, on two unsolved Problems in Indo-German Philology;—Dr. T. Williams, Report on the British Annelida;—R. Mallet, Second Report on the Facts of Earthquake Phenomena;—Letter from Prof. Henry to Col. Sabine, on the System of Meteorological Observations proposed to be established in the United States;—Col. Sabine, Report on the Kew Magnetographs;—J. Welsh, Report on the Performance of his three Magnetographs during the Experimental Trial at the Kew Observatory;—F. Ronalds, Report concerning the Observatory of the British Association at Kew, from September 12, 1850 to July 31, 1851;—Ordnance Survey of Scotland.

Together with the Transactions of the Sections, Prof. Airy's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-SECOND MEETING, at Belfast, 1852, *Published at* 15*s.*

Contents:—R. Mallet, Third Report on the Facts of Earthquake Phenomena;—Twelfth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1851–52;—Dr. Gladstone, on the Influence of the Solar Radiations on the Vital Powers of Plants;—A Manual of Ethnological Inquiry;—Col. Sykes, Mean Temperature of the Day, and Monthly Fall of Rain at 127 Stations under the Bengal Presidency;—Prof. J. D. Forbes, on Experiments on the Laws of the Conduction of Heat;—R. Hunt, on the Chemical Action of the Solar Radiations;—Dr. Hodges, on the Composition and Economy of the Flax Plant;—W. Thompson, on the Freshwater Fishes of Ulster;—W. Thompson, Supplementary Report on the Fauna of Ireland;—W. Wills, on the Meteorology of Birmingham;—J. Thomson, on the Vortex-Water-Wheel;—J. B. Lawes and Dr. Gilbert, on the Composition of Foods in relation to Respiration and the Feeding of Animals.

Together with the Transactions of the Sections, Colonel Sabine's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-THIRD MEETING, at Hull, 1853, *Published at* 10*s*. 6*d*.

CONTENTS:—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1852–53; —James Oldham, on the Physical Features of the Humber;—James Oldham, on the Rise, Progress, and Present Position of Steam Navigation in Hull;—William Fairbairn, Experimental Researches to determine the Strength of Locomotive Boilers, and the causes which lead to Explosion;—J. J. Sylvester, Provisional Report on the Theory of Determinants;—Professor Hodges, M.D., Report on the Gases evolved in Steeping Flax, and on the Composition and Economy of the Flax Plant;—Thirteenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Robert Hunt, on the Chemical Action of the Solar Radiations; —John P. Bell, M.D., Observations on the Character and Measurements of Degradation of the Yorkshire Coast; First Report of Committee on the Physical Character of the Moon's Surface, as compared with that of the Earth;—R. Mallet, Provisional Report on Earthquake Wave-Transits; and on Seismometrical Instruments;—William Fairbairn, on the Mechanical Properties of Metals as derived from repeated Meltings, exhibiting the maximum point of strength and the causes of deterioration;—Robert Mallet, Third Report on the Facts of Earthquake Phenomena (continued).

Together with the Transactions of the Sections, Mr. Hopkins's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-FOURTH MEETING, at Liverpool, 1854, *Published at* 18*s*.

CONTENTS:—R. Mallet, Third Report on the Facts of Earthquake Phenomena (continued); —Major-General Chesney, on the Construction and General Use of Efficient Life-Boats;—Rev. Prof. Powell, Third Report on the present State of our Knowledge of Radiant Heat;—Colonel Sabine, on some of the results obtained at the British Colonial Magnetic Observatories;—Colonel Portlock, Report of the Committee on Earthquakes, with their proceedings respecting Seismometers;—Dr. Gladstone, on the influence of the Solar Radiations on the Vital Powers of Plants, Part 2;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1853–54; —Second Report of the Committee on the Physical Character of the Moon's Surface;—W. G. Armstrong, on the Application of Water-Pressure Machinery;—J. B. Lawes and Dr. Gilbert, on the Equivalency of Starch and Sugar in Food;—Archibald Smith, on the Deviations of the Compass in Wooden and Iron Ships;—Fourteenth Report of Committee on Experiments on the Growth and Vitality of Seeds.

Together with the Transactions of the Sections, the Earl of Harrowby's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-FIFTH MEETING, at Glasgow, 1855, *Published at* 15*s*.

CONTENTS:—T. Dobson, Report on the Relation between Explosions in Coal-Mines and Revolving Storms;—Dr. Gladstone, on the Influence of the Solar Radiations on the Vital Powers of Plants growing under different Atmospheric Conditions, Part 3;—C. Spence Bate, on the British Edriophthalma;—J. F. Bateman, on the present state of our knowledge on the Supply of Water to Towns;—Fifteenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1854–55; —Report of Committee appointed to inquire into the best means of ascertaining those properties of Metals and effects of various modes of treating them which are of importance to the durability and efficiency of Artillery;—Rev. Prof. Henslow, Report on Typical Objects in Natural History;—A. Follett Osler, Account of the Self-Registering Anemometer and Rain-Gauge at the Liverpool Observatory;—Provisional Reports.

Together with the Transactions of the Sections, the Duke of Argyll's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-SIXTH MEETING, at Cheltenham, 1856, *Published at* 18*s*.

CONTENTS:—Report from the Committee appointed to investigate and report upon the effects produced upon the Channels of the Mersey by the alterations which within the last fifty years have been made in its Banks;—J. Thomson, Interim Report on progress in Researches on the Measurement of Water by Weir Boards;—Dredging Report, Frith of Clyde, 1856;—Rev. B. Powell, Report on Observations of Luminous Meteors, 1855–1856;—Prof. Bunsen and Dr. H. E. Roscoe, Photochemical Researches;—Rev. James Booth, on the Trigo-

nometry of the Parabola, and the Geometrical Origin of Logarithms;—R. MacAndrew, Report on the Marine Testaceous Mollusca of the North-east Atlantic and Neighbouring Seas, and the physical conditions affecting their development;—P. P. Carpenter, Report on the present state of our knowledge with regard to the Mollusca of the West Coast of North America;—T. C. Eyton, Abstract of First Report on the Oyster Beds and Oysters of the British Shores; —Prof. Phillips, Report on Cleavage and Foliation in Rocks, and on the Theoretical Explanations of these Phenomena: Part I.;—Dr. T. Wright on the Stratigraphical Distribution of the Oolitic Echinodermata;—W. Fairbairn, on the Tensile Strength of Wrought Iron at various Temperatures;—C. Atherton, on Mercantile Steam Transport Economy;—J. S. Bowerbank, on the Vital Powers of the Spongiadæ;—Report of a Committee upon the Experiments conducted at Stormontfield, near Perth, for the artificial propagation of Salmon;—Provisional Report on the Measurement of Ships for Tonnage;—On Typical Forms of Minerals, Plants and Animals for Museums;—J. Thomson, Interim Report on Progress in Researches on the Measurement of Water by Weir Boards;—R. Mallet, on Observations with the Seismometer;—A. Cayley, on the Progress of Theoretical Dynamics;—Report of a Committee appointed to consider the formation of a Catalogue of Philosophical Memoirs.

Together with the Transactions of the Sections, Dr. Daubeny's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-SEVENTH MEETING, at Dublin, 1857, *Published at* 15*s*.

CONTENTS:—A. Cayley, Report on the Recent Progress of Theoretical Dynamics;—Sixteenth and final Report of Committee on Experiments on the Growth and Vitality of Seeds; —James Oldham, C.E., continuation of Report on Steam Navigation at Hull;—Report of a Committee on the Defects of the present methods of Measuring and Registering the Tonnage of Shipping, as also of Marine Engine-Power, and to frame more perfect rules, in order that a correct and uniform principle may be adopted to estimate the Actual Carrying Capabilities and Working-Power of Steam Ships;—Robert Were Fox, Report on the Temperature of some Deep Mines in Cornwall;—Dr. G. Plarr, De quelques Transformations de la Somme $\Sigma_0^{-\alpha} t \frac{\alpha^{t|+1}\beta^{t|+1}\delta^{t|+1}}{1^{t|+1}\gamma^{t|+1}\epsilon^{t|+1}}$, α étant entier négatif, et de quelques cas dans lesquels cette somme est exprimable par une combinaison de factorielles, la notation $a^{t|+1}$ désignant le produit des t facteurs $a\ (a+1)\ (a+2)$ &c....$(a+t-1)$;—G. Dickie, M.D., Report on the Marine Zoology of Strangford Lough, County Down, and corresponding part of the Irish Channel;—Charles Atherton, Suggestions for Statistical Inquiry into the extent to which Mercantile Steam Transport Economy is affected by the Constructive Type of Shipping, as respects the Proportions of Length, Breadth, and Depth;—J. S. Bowerbank, Further Report on the Vitality of the Spongiadæ;—John P. Hodges, M.D., on Flax;—Major-General Sabine, Report of the Committee on the Magnetic Survey of Great Britain;—Rev. Baden Powell, Report on Observations of Luminous Meteors, 1856–57;—C. Vignoles, C.E., on the Adaptation of Suspension Bridges to sustain the passage of Railway Trains;—Professor W. A. Miller, M.D., on Electro-Chemistry; —John Simpson, R.N., Results of Thermometrical Observations made at the 'Plover's' Wintering-place, Point Barrow, latitude 71° 21′ N., long. 156° 17′ W., in 1852–54;—Charles James Hargreave, LL.D., on the Algebraic Couple; and on the Equivalents of Indeterminate Expressions;—Thomas Grubb, Report on the Improvement of Telescope and Equatorial Mountings;—Professor James Buckman, Report on the Experimental Plots in the Botanical Garden of the Royal Agricultural College at Cirencester;—William Fairbairn on the Resistance of Tubes to Collapse;—George C. Hyndman, Report of the Proceedings of the Belfast Dredging Committee;—Peter W. Barlow, on the Mechanical Effect of combining Girders and Suspension Chains, and a Comparison of the Weight of Metal in Ordinary and Suspension Girders, to produce equal deflections with a given load;—J. Park Harrison, M.A., Evidences of Lunar Influence on Temperature;—Report on the Animal and Vegetable Products imported into Liverpool from the year 1851 to 1855 (inclusive);—Andrew Henderson, Report on the Statistics of Life-boats and Fishing-boats on the Coasts of the United Kingdom.

Together with the Transactions of the Sections, Rev. H. Lloyd's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-EIGHTH MEETING, at Leeds, September 1858, *Published at* 20*s*.

CONTENTS:—R. Mallet, Fourth Report upon the Facts and Theory of Earthquake Phenomena;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1857–58;—R. H. Meade, on some Points in the Anatomy of the Araneidea or true Spiders, especially on the

Internal structure of their Spinning Organs;—W. Fairbairn, Report of the Committee on the Patent Laws;—S. Eddy, on the Lead Mining Districts of Yorkshire;—W. Fairbairn, on the Collapse of Glass Globes and Cylinders;—Dr. E. Perceval Wright and Prof. J. Reay Greene, Report on the Marine Fauna of the South and West Coasts of Ireland;—Prof. J. Thomson, on Experiments on the Measurement of Water by Triangular Notches in Weir Boards;—Major-General Sabine, Report of the Committee on the Magnetic Survey of Great Britain;—Michael Connal and William Keddie, Report on Animal, Vegetable, and Mineral Substances imported from Foreign Countries into the Clyde (including the Ports of Glasgow, Greenock, and Port Glasgow) in the years 1853, 1854, 1855, 1856, and 1857;—Report of the Committee on Shipping Statistics;—Rev. H. Lloyd, D.D., Notice of the Instruments employed in the Magnetic Survey of Ireland, with some of the Results;—Prof. J. R. Kinahan, Report of Dublin Dredging Committee, appointed 1857–58;—Prof. J. R. Kinahan, Report on Crustacea of Dublin District;—Andrew Henderson, on River Steamers, their Form, Construction, and Fittings, with reference to the necessity for improving the present means of Shallow-Water Navigation on the Rivers of British India;—George C. Hyndman, Report of the Belfast Dredging Committee;—Appendix to Mr. Vignoles's paper "On the Adaptation of Suspension Bridges to sustain the passage of Railway Trains;"—Report of the Joint Committee of the Royal Society and the British Association, for procuring a continuance of the Magnetic and Meteorological Observatories;—R. Beckley, Description of a Self-recording Anemometer.

Together with the Transactions of the Sections, Prof. Owen's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-NINTH MEETING, at Aberdeen, September 1859, *Published at* 15*s*.

CONTENTS:—George C. Foster, Preliminary Report on the Recent Progress and Present State of Organic Chemistry;—Professor Buckman, Report on the Growth of Plants in the Garden of the Royal Agricultural College, Cirencester;—Dr. A. Voelcker, Report on Field Experiments and Laboratory Researches on the Constituents of Manures essential to cultivated Crops;—A. Thomson, Esq. of Banchory, Report on the Aberdeen Industrial Feeding Schools;—On the Upper Silurians of Lesmahago, Lanarkshire;—Alphonse Gages, Report on the Results obtained by the Mechanico-Chemical Examination of Rocks and Minerals;—William Fairbairn, Experiments to determine the Efficiency of Continuous and Self-acting Breaks for Railway Trains;—Professor J. R. Kinahan, Report of Dublin Bay Dredging Committee for 1858–59;—Rev. Baden Powell, Report on Observations of Luminous Meteors for 1858–59;—Professor Owen, Report on a Series of Skulls of various Tribes of Mankind inhabiting Nepal, collected, and presented to the British Museum, by Bryan H. Hodgson, Esq., late Resident in Nepal, &c. &c.;—Messrs. Maskelyne, Hadow, Hardwich, and Llewelyn, Report on the Present State of our Knowledge regarding the Photographic Image;—G. C. Hyndman, Report of the Belfast Dredging Committee for 1859;—James Oldham, Continuation of Report of the Progress of Steam Navigation at Hull;—Charles Atherton, Mercantile Steam Transport Economy as affected by the Consumption of Coals;—Warren de la Rue, Report on the present state of Celestial Photography in England;—Professor Owen, on the Orders of Fossil and Recent Reptilia, and their Distribution in Time;—Balfour Stewart, on some Results of the Magnetic Survey of Scotland in the years 1857 and 1858, undertaken, at the request of the British Association, by the late John Welsh, Esq., F.R.S.;—W. Fairbairn, The Patent Laws: Report of Committee on the Patent Laws,—J. Park Harrison, Lunar Influence on the Temperature of the Air;—Balfour Stewart, an Account of the Construction of the Self-recording Magnetographs at present in operation at the Kew Observatory of the British Association;—Prof. H. J. Stephen Smith, Report on the Theory of Numbers, Part I.;—Report of the Committee on Steamship performance;—Report of the Proceedings of the Balloon Committee of the British Association appointed at the Meeting at Leeds;—Prof. William K. Sullivan, Preliminary Report on the Solubility of Salts at Temperatures above 100° Cent., and on the Mutual Action of Salts in Solution.

Together with the Transactions of the Sections, Prince Albert's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTIETH MEETING, at Oxford, June and July 1860, *Published at* 15*s*.

CONTENTS:—James Glaisher, Report on Observations of Luminous Meteors, 1859–60;—J. R. Kinahan, Report of Dublin Bay Dredging Committee;—Rev. J. Anderson, Report on the Excavations in Dura Den;—Professor Buckman, Report on the Experimental Plots in the Botanical Garden of the Royal Agricultural College, Cirencester;—Rev. R. Walker, Report of

the Committee on Balloon Ascents;—Prof. W. Thomson, Report of Committee appointed to prepare a Self-recording Atmospheric Electrometer for Kew, and Portable Apparatus for observing Atmospheric Electricity;—William Fairbairn, Experiments to determine the Effect of Vibratory Action and long-continued Changes of Load upon Wrought-iron Girders;—R. P. Greg, Catalogue of Meteorites and Fireballs, from A.D. 2 to A.D. 1860;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part II.;—Vice-Admiral Moorsom, on the Performance of Steam-vessels, the Functions of the Screw, and the Relations of its Diameter and Pitch to the Form of the Vessel;—Rev. W. V. Harcourt, Report on the Effects of long-continued Heat, illustrative of Geological Phenomena;—Second Report of the Committee on Steamship Performance;—Interim Report on the Gauging of Water by Triangular Notches;—List of the British Marine Invertebrate Fauna.

Together with the Transactions of the Sections, Lord Wrottesley's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-FIRST MEETING, at Manchester, September 1861, *Published at £1.*

CONTENTS:—James Glaisher, Report on Observations of Luminous Meteors;—Dr. E. Smith, Report on the Action of Prison Diet and Discipline on the Bodily Functions of Prisoners, Part I.;—Charles Atherton, on Freight as affected by Differences in the Dynamic Properties of Steamships;—Warren De la Rue, Report on the Progress of Celestial Photography since the Aberdeen Meeting;—B. Stewart, on the Theory of Exchanges, and its recent extension;—Drs. E. Schunck, R. Angus Smith, and H. E. Roscoe, on the Recent Progress and Present Condition of Manufacturing Chemistry in the South Lancashire District;—Dr. J. Hunt, on Ethno-Climatology; or, the Acclimatization of Man;—Prof. J. Thomson, on Experiments on the Gauging of Water by Triangular Notches;—Dr. A. Voelcker, Report on Field Experiments and Laboratory Researches on the Constituents of Manures essential to cultivated Crops;—Prof. H. Hennessy, Provisional Report on the Present State of our Knowledge respecting the Transmission of Sound-signals during Fogs at Sea;—Dr. P. L. Sclater and F. von Hochstetter, Report on the Present State of our Knowledge of the Birds of the Genus *Apteryx* living in New Zealand;—J. G. Jeffreys, Report of the Results of Deep-sea Dredging in Zetland, with a Notice of several Species of Mollusca new to Science or to the British Isles;—Prof. J. Phillips, Contributions to a Report on the Physical Aspect of the Moon;—W. R. Birt, Contribution to a Report on the Physical Aspect of the Moon;—Dr. Collingwood and Mr. Byerley, Preliminary Report of the Dredging Committee of the Mersey and Dee;—Third Report of the Committee on Steamship Performance;—J. G. Jeffreys, Preliminary Report on the Best Mode of preventing the Ravages of *Teredo* and other Animals in our Ships and Harbours;—R. Mallet, Report on the Experiments made at Holyhead to ascertain the Transit-Velocity of Waves, analogous to Earthquake Waves, through the local Rock Formations;—T. Dobson, on the Explosions in British Coal-Mines during the year 1859;—J. Oldham, Continuation of Report on Steam Navigation at Hull;—Professor G. Dickie, Brief Summary of a Report on the Flora of the North of Ireland;—Professor Owen, on the Psychical and Physical Characters of the Mincopies, or Natives of the Andaman Islands, and on the Relations thereby indicated to other Races of Mankind;—Colonel Sykes, Report of the Balloon Committee;—Major-General Sabine, Report on the Repetition of the Magnetic Survey of England;—Interim Report of the Committee for Dredging on the North and East Coasts of Scotland;—W. Fairbairn, on the Resistance of Iron Plates to Statical Pressure and the Force of Impact by Projectiles at High Velocities;—W. Fairbairn, Continuation of Report to determine the effect of Vibratory Action and long-continued Changes of Load upon Wrought-Iron Girders;—Report of the Committee on the Law of Patents;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part III.

Together with the Transactions of the Sections, Mr. Fairbairn's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-SECOND MEETING, at Cambridge, October 1862, *Published at £1.*

CONTENTS:—James Glaisher, Report on Observations of Luminous Meteors, 1861–62;—G. B. Airy, on the Strains in the Interior of Beams;—Archibald Smith and F. J. Evans, Report on the three Reports of the Liverpool Compass Committee;—Report on Tidal Observations on the Humber;—T. Aston, on Rifled Guns and Projectiles adapted for Attacking

Armour-plate Defences;—Extracts, relating to the Observatory at Kew, from a Report presented to the Portuguese Government, by Dr. J. A. de Souza;—H. T. Mennell, Report on the Dredging of the Northumberland Coast and Dogger Bank;—Dr. Cuthbert Collingwood, Report upon the best means of advancing Science through the agency of the Mercantile Marine;—Messrs. Williamson, Wheatstone, Thomson, Miller, Matthiessen, and Jenkin, Provisional Report on Standards of Electrical Resistance;—Preliminary Report of the Committee for investigating the Chemical and Mineralogical Composition of the Granites of Donegal;—Prof. H. Hennessy, on the Vertical Movements of the Atmosphere considered in connexion with Storms and Changes of Weather;—Report of Committee on the application of Gauss's General Theory of Terrestrial Magnetism to the Magnetic Variations;—Fleeming Jenkin, on Thermo-electric Currents in Circuits of one Metal;—W. Fairbairn, on the Mechanical Properties of Iron Projectiles at High Velocities;—A. Cayley, Report on the Progress of the Solution of certain Special Problems of Dynamics;—Prof. G. G. Stokes, Report on Double Refraction;—Fourth Report of the Committee on Steamship Performance;—G. J. Symons, on the Fall of Rain in the British Isles in 1860 and 1861;—J. Ball, on Thermometric Observations in the Alps;—J. G. Jeffreys, Report of the Committee for Dredging on the N. and E. Coasts of Scotland;—Report of the Committee on Technical and Scientific Evidence in Courts of Law;—James Glaisher, Account of Eight Balloon Ascents in 1862;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part IV.

Together with the Transactions of the Sections, the Rev. Prof. R. Willis's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-THIRD MEETING, at Newcastle-upon-Tyne, August and September 1863, *Published at £1 5s.*

CONTENTS:—Report of the Committee on the Application of Gun-cotton to Warlike Purposes;—A. Matthiessen, Report on the Chemical Nature of Alloys;—Report of the Committee on the Chemical and Mineralogical Constitution of the Granites of Donegal, and of the Rocks associated with them;—J. G. Jeffreys, Report of the Committee appointed for Exploring the Coasts of Shetland by means of the Dredge;—G. D. Gibb, Report on the Physiological Effects of the Bromide of Ammonium;—C. K Aken, on the Transmutation of Spectral Rays, Part I.:—Dr. Robinson, Report of the Committee on Fog Signals,—Report of the Committee on Standards of Electrical Resistance;—E. Smith, Abstract of Report by the Indian Government on the Foods used by the Free and Jail Populations in India;—A. Gages, Synthetical Researches on the Formation of Minerals, &c.;—R. Mallet, Preliminary Report on the Experimental Determination of the Temperatures of Volcanic Foci, and of the Temperature, State of Saturation, and Velocity of the issuing Gases and Vapours;—Report of the Committee on Observations of Luminous Meteors;—Fifth Report of the Committee on Steamship Performance; G. J. Allman, Report on the Present State of our Knowledge of the Reproductive System in the Hydroida;—J Glaisher, Account of Five Balloon Ascents made in 1863;—P. P. Carpenter, Supplementary Report on the Present State of our Knowledge with regard to the Mollusca of the West Coast of North America;—Professor Airy, Report on Steam-boiler Explosions;—C. W. Siemens, Observations on the Electrical Resistance and Electrification of some Insulating Materials under Pressures up to 300 Atmospheres;—C. M. Palmer, on the Construction of Iron Ships and the Progress of Iron Shipbuilding on the Tyne, Wear, and Tees;—Messrs. Richardson, Stevenson, and Clapham, on the Chemical Manufactures of the Northern Districts;—Messrs. Sopwith and Richardson, on the Local Manufacture of Lead, Copper, Zinc, Antimony, &c;—Messrs. Daglish and Forster, on the Magnesian Limestone of Durham;—I. L. Bell, on the Manufacture of Iron in connexion with the Northumberland and Durham Coal-field;—T. Spencer, on the Manufacture of Steel in the Northern District;—H. J. S. Smith, Report on the Theory of Numbers, Part V.

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PROCEEDINGS OF THE THIRTY-FOURTH MEETING, at Bath, September 1864. *Published* at 18s.

CONTENTS:—Report of the Committee for Observations of Luminous Meteors;—Report of the Committee on the best means of providing for a Uniformity of Weights and Measures;—T. S. Cobbold, Report of Experiments respecting the Development and Migration of the Entozoa;—B. W. Richardson, Report on the Physiological Action of Nitrite of Amyl;—J. Oldham, Report of the Committee on Tidal Observations;—G. S. Brady, Report on deep-sea Dredging on the Coasts of Northumberland and Durham in 1864;—J. Glaisher,

Account of Nine Balloon Ascents made in 1863 and 1864;—J. G. Jeffreys, Further Report on Shetland Dredgings;—Report of the Committee on the Distribution of the Organic Remains of the North Staffordshire Coal-field;—Report of the Committee on Standards of Electrical Resistance;—G. J. Symons, on the Fall of Rain in the British Isles in 1862 and 1863;—W. Fairbairn, Preliminary Investigation of the Mechanical Properties of the proposed Atlantic Cable.

Together with the Transactions of the Sections, Sir Charles Lyell's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-FIFTH MEETING, at Birmingham, September 1865, *Published at £1 5s.*

CONTENTS:—J. G. Jeffreys, Report on Dredging among the Channel Isles;—F. Buckland, Report on the Cultivation of Oysters by Natural and Artificial Methods;—Report of the Committee for exploring Kent's Cavern;—Report of the Committee on Zoological Nomenclature;—Report on the Distribution of the Organic Remains of the North Staffordshire Coal-field;—Report on the Marine Fauna and Flora of the South Coast of Devon and Cornwall;—Interim Report on the Resistance of Water to Floating and Immersed Bodies;—Report on Observations of Luminous Meteors;—Report on Dredging on the Coast of Aberdeenshire;—J. Glaisher, Account of Three Balloon Ascents;—Interim Report on the Transmission of Sound under Water;—G. J. Symons, on the Rainfall of the British Isles;—W. Fairbairn, on the Strength of Materials considered in relation to the Construction of Iron Ships;—Report of the Gun-Cotton Committee;—A. F. Osler, on the Horary and Diurnal Variations in the Direction and Motion of the Air at Wrottesley, Liverpool, and Birmingham;—B. W. Richardson, Second Report on the Physiological Action of certain of the Amyl Compounds;—Report on further Researches in the Lingula-flags of South Wales;—Report of the Lunar Committee for Mapping the Surface of the Moon;—Report on Standards of Electrical Resistance;—Report of the Committee appointed to communicate with the Russian Government respecting Magnetical Observations at Tiflis;—Appendix to Report on the Distribution of the Vertebrate Remains from the North Staffordshire Coal-field;—H. Woodward, First Report on the Structure and Classification of the Fossil Crustacea;—H. J. S. Smith, Report on the Theory of Numbers, Part VI.;—Report on the best means of providing for a Uniformity of Weights and Measures, with reference to the interests of Science;—A. G. Findlay, on the Bed of the Ocean;—Professor A. W. Williamson, on the Composition of Gases evolved by the Bath Spring called King's Bath.

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PROCEEDINGS OF THE THIRTY-SIXTH MEETING, at Nottingham, August 1866, *Published at £1 4s.*

CONTENTS:—Second Report on Kent's Cavern, Devonshire;—A. Matthiessen, Preliminary Report on the Chemical Nature of Cast Iron;—Report on Observations of Luminous Meteors;—W. S. Mitchell, Report on the Alum Bay Leaf-bed;—Report on the Resistance of Water to Floating and Immersed Bodies;—Dr. Norris, Report on Muscular Irritability;—Dr. Richardson, Report on the Physiological Action of certain compounds of Amyl and Ethyl;—H. Woodward, Second Report on the Structure and Classification of the Fossil Crustacea;—Second Report on the "Menevian Group," and the other Formations at St. David's, Pembrokeshire;—J. G. Jeffreys, Report on Dredging among the Hebrides;—Rev. A. M. Norman, Report on the Coasts of the Hebrides, Part II.;—J. Alder, Notices of some Invertebrata, in connexion with Mr. Jeffreys's Report;—G. S. Brady, Report on the *Ostracoda* dredged amongst the Hebrides;—Report on Dredging in the Moray Firth;—Report on the Transmission of Sound-Signals under Water;—Report of the Lunar Committee;—Report of the Rainfall Committee;—Report on the best means of providing for a Uniformity of Weights and Measures, with reference to the Interests of Science;—J. Glaisher, Account of Three Balloon Ascents;—Report on the Extinct Birds of the Mascarene Islands;—Report on the penetration of Iron-clad Ships by Steel Shot;—J. A. Wanklyn, Report on Isomerism among the Alcohols;—Report on Scientific Evidence in Courts of Law;—A. L. Adams, Second Report on Maltese Fossiliferous Caves, &c.

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1868.

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1864. *Ainsworth, David. The Flosh, Egremont, Cumberland.
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1842. *Ainsworth, Thomas. The Flosh, Egremont, Cumberland.
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1865. *Avery, William Henry. Digbeth, Birmingham.
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1846. ‡Banks, Rev. S. H., LL D. Dullingham, Newmarket.
1842. *Bannerman, Alexander.*
1861. ‡Bannerman, James Alexander. Limefield House, Higher Broughton, near Manchester.
1853. ‡*Bannister, Anthony.*
1866. §Barber, John. Long-row, Nottingham.
1861. *Barbour, George. Bolesworth Castle, Tattenhall, Chester.
1859. ‡Barbour, George F. Bouskeid, Edinburgh.
*Barbour, Robert. Bolesworth Castle, Chester.
1855. ‡Barclay, Andrew. Kilmarnock, Scotland.
Barclay, Charles, F.S.A., M.R.A.S. Bury-hill, Dorking.
Barclay, James. Catrine, Ayrshire.
1852. *Barclay, J. Gurney. Walthamstow, Essex.
1860. *Barclay, Robert. Leyton, Essex.
1863. ‡Barford, James Gale. Wellington College, Berkshire.
1860. *Barker, Rev. Arthur Alcock, B.D. East Bridgeford Rectory, Notts.
1857. ‡Barker, John, M.D., Curator of the Royal College of Surgeons of Ireland. Dublin.
1865. ‡Barker, Stephen. 30 Frederick-street, Edgbaston, Birmingham.
1846. ‡Barlow, Rev. John, M.A., F.R.S., F.L.S., F.G.S. 5 Berkeley-street, London, W.
Barlow, Lieut.-Col. Maurice (14th Regt. of Foot). 5 Great George-street, Dublin.
Barlow, Peter. 5 Great George-street, Dublin.
1857. ‡Barlow, Peter William, F.R.S., F.G.S. 26 Great George-street, London, S.W.
1861. *Barnard, Major R. Cary. Cambridge House, Bays-hill, Cheltenham.
1864. *Barneby, John H. Brockhampton Park, Worcester.
Barnes, Rev. Joseph Watkins, M.A. Kendal, Westmoreland.
*Barnes, Thomas, M.D., F.R.S.E. Carlisle.

Year of Election.

Barnes, Thomas Addison. 2 Wellesley-villas, Soho Park, Birmingham.
*Barnett, Richard, M.R.C.S. Coten End, Warwickshire.
1859. ‡Barr, Lieut.-Colonel, Bombay Army. (Messrs. Forbes, Forbes & Co., 9 King William-street, London.)
1861. *Barr, W. R. Norris Bank, Heaton Norris, Stockport.
1860. ‡Barrett, T. B. High-street, Welshpool, Montgomery.
1852. ‡Barrington, Edward. Fassaroe Bray, Co. Wicklow.
1852. ‡Barrington, Richard S. Trafalgar-terrace, Monkstown, Co. Dublin.
1866. ‡Barron, William. Elvaston Nurseries, Borrowash, Derby.
1863. ‡Barrow, Capt. C. J. Southwell.
1858. ‡*Barry, Rev. A.*
1862. *Barry, Charles. Lapswood, Sydenham-hill, Kent.
Barstow, Thomas. Garrow-hill, near York.
1858. *Bartholomew, Charles. Broxholme, Doncaster.
1855. ‡Bartholomew, Hugh. New Gas-works, Glasgow.
1858. *Bartholomew, William Hamond. 5 Grove-terrace, Leeds.
1851. ‡Bartlet, A. H. Lower Brook-street, Ipswich.
1857. ‡Barton, Folloit W. Clonelly, Co. Fermanagh.
1852. ‡Barton, James. Farndreg, Dundalk.
*Barton, John. Bank of Ireland, Dublin.
1864. §Bartrum, John S. 41 Gay-street, Bath.
1858. *Barwick, John Marshall. Albion-street, Leeds.
*Bashforth, Rev. Francis, B.D. Minting, near Horncastle, Lincolnshire.
1861. ‡Bass, John H., F.G.S. 287 Camden-road, London, N.
1866. *Bassett, Henry. 19 Alfred-place, Bedford-square, London, W.C.
1866. ‡Bassett, Richard. Pelham-street, Nottingham.
1850. ‡Bastard, Thomas H. Charleton, Blandford.
1848. ‡Bate, C. Spence, F.R.S., F.L.S. 8 Mulgrave-place, Plymouth.
Bateman, James, M.A., F.R S., F.L.S., F.H.S. Biddulph Grange, near Congleton, Staffordshire.
1842. *Bateman, John Frederic, C.E., F.R.S., F.G.S. 16 Great George-street, London, S.W.
*Bateman, Joseph, LL.D., F.R.A.S. Walthamstow, London, N.E.
1864. §Bates, Henry Walter, Assist.-Sec. R.G.S. 15 Whitehall-place, London, S.W.
Bateson, John Glynn. Liverpool.
1852. ‡Bateson, Sir Robert, Bart. Belvoir Park, Belfast.
1863. *Bathurst, Rev. W. H. Lydney Park, Gloucestershire.
1863. §Bauerman, Henry, F.G.S. 22 Acre-lane, Brixton, London, S.
1861. ‡Baxendell, Joseph, F.R.A.S. 108 Stock-street, Manchester.
1867. *Baxter, Sir David, Bart. Kilmaron, Fifeshire.
1867. §Baxter, Edward. Hazel Hall, Dundee.
1867. §Baxter, John B. Craig Tay House, Dundee.
1858. ‡*Baxter, Robert.*
1867. §Baxter, William Edward, M.P. Ashcliffe, Dundee.
*Bayldon, John. Horbury, near Wakefield.
1851. *Bayley, George. 2 Cowper's-court, Cornhill, London, E.C.
1866. §Bayley, Thomas. Lenton, Nottingham.
1854. ‡Baylis, C. O., M.D. 51 Hamilton-square, Birkenhead.
1855. ‡*Bayly, Capt., R.E.*
Bayly, John. 1 Brunswick-terrace, Plymouth.
1842. Bazley, Thomas Sebastian, B.A. Agden Hall, Lymm, Warrington.
Beal, Captain. Toronto, Upper Canada.
1860. *Beale, Lionel S., M.B., F.R.S., Professor of Physiology and of General and Morbid Anatomy in King's College, London. 61 Grosvenor-street, London, W.
Beamish, Francis B.

Year of Election.

1833. *Beamish, Richard, F.R.S. (*Local Treasurer.*) Woolston Lawn, Woolston, Southampton.
1861. §Bean, William. Alfreton, Derbyshire.
1866. *Beardmore, Nathaniel. 30 Great George-street, London, S.W.
*Beatson, William. Rotherham.
1857. ‡*Beattie, Joseph.*
1855. **Beaufort, William Morris, F.R.G.S. India.*
1861. *Beaumont, Rev. Thomas George. Chelmondiston Rectory, Ipswich.
1865. §Beavan, Hugh J. C., F.R.G.S. 4 Middle Temple-lane, London, E.C.
1859. *Beck, Joseph, F.R.A.S. 31 Cornhill, London, E.C.
1851. ‡*Becker, Ernest, Ph.D. Darmstadt.*
1864. §Becker, Miss L. E. 10 Grove-street, Ardwick, Manchester.
1858. *Beckett, William. Kirkstall Grange, Leeds.
1860. ‡Beckles, Samuel H., F.R.S., F.G.S. Enden-villas, Schiest-road, South Norwood, London, S.
1866. ‡Beddard, James. Derby-road, Nottingham.
1846. ‡Beddome, J., M.D. Romsey, Hampshire.
1854. ‡*Bedford, James, Ph.D.*
1858. ‡*Bedford, James.*
1850. ‡Begbie, James, M.D. 21 Alva-street, Edinburgh.
1846. ‡Beke, Charles T., Ph.D., F.S.A., F.R.G.S. Bekesbourne House, near Canterbury, Kent.
1865. *Belavenetz, I., Captain of the Russian Imperial Navy, F.R.I.G.S., M.S.C.M.A., Superintendent of the Compass Observatory, Cronstadt. (Care of Messrs. Baring Brothers, Bishopsgate-street, London, E.C.)
1847. *Belcher, Vice-Admiral Sir Edward, K.C.B., F.R.A.S., F.R.G.S. 22A Connaught-square, London, W.
1847. ‡Belcher, William. Abingdon.
1850. ‡Bell, Charles, M.D. 3 St. Colme-street, Edinburgh.
Bell, Frederick John. Woodlands, near Maldon, Essex.
1859. ‡Bell, George. Windsor-buildings, Dumbarton.
1860. ‡Bell, Rev. George Charles, M.A. The College, Dulwich, Surrey, S.
1855. ‡Bell, Capt. Henry. Chalfont Lodge, Cheltenham.
1862. *Bell, Isaac Lowthian. The Hall, Washington, Co. Durham.
1853. ‡Bell, John Pearson, M.D. Waverley House, Hull.
*Bell, Matthew P. 245 St. Vincent-street, Glasgow.
1859. ‡Bell, Robert, jun. 3 Airlie-place, Dundee.
1864. ‡Bell, R. Queen's College, Kingston, Canada.
Bell, Thomas, F.R.S., F.L.S., F.G.S., Professor of Zoology, King's College, London. The Wakes, Selborne, near Alton, Hants.
1863. *Bell, Thomas. Usworth House, Gateshead, Durham.
1867. §Bell, Thomas. Belmont, Dundee.
1842. Bellhouse, Edward Taylor. Eagle Foundry, Manchester.
1854. ‡Bellhouse, William Dawson. 1 Park-street, Leeds.
Bellingham, Sir Alan. Castle Bellingham, Ireland.
1866. *Belper, The Right Hon. Lord, M.A., F.R.S., F.G.S. 88 Eaton-square, London, S.W.; and Kingston Hall, Nottingham.
1864. **Bendyshe, T.*
1848. ‡Benham, E. 18 Essex-street, Strand, London, W.C.
1850. ‡Bennett, John Hughes, M.D., F.R.S.E., Professor of Institutes of Medicine in the University of Edinburgh. 1 Glenfinlas-street, Edinburgh.
1852. *Bennoch, Francis. The Knoll, Blackheath, Kent.
1857. ‡Benson, Charles. 11 Fitzwilliam-square West, Dublin.
Benson, Robert, jun. Fairfield, Manchester.
1848. ‡Benson, Starling, F.G.S. Gloucester-place, Swansea.
1863. ‡Benson, William. Fourstones Court, Newcastle-on-Tyne.

Year of Election.

1848. ‡Bentham, George, F.R.S., Pres. L.S. 26 Wilton-place, Knightsbridge, London, S.W.
Bethune, Rear-Admiral, C.B., F.R.G.S. Balfour, Fifeshire.
1842. Bentley, John. 9 Portland-place, London, W.
1845. ‡Bentley, J. Flowers. Stamford, Lincolnshire.
1863. §Bentley, Robert, F.L.S., Professor of Botany in King's College. 55 Clifton-road, St. John's-wood, London, N.W.
1865. §Berger, C. H., F.C.S. Lower Clapton, London, N.E.
1863. ‡Berkley, C. Marley Hill, Gateshead, Durham.
1848. ‡Berrington, Arthur V. D. Woodlands Castle, near Swansea.
1866. §Berry, Rev. Arthur George. The Grove, Stainton-by-Dale, Nottingham.
*Berryman, William Richard. 6 Tamar-terrace, Stoke, Devonport.
1862. ‡Besant, William Henry, M.A. St. John's College, Cambridge.
1865. §Bessemer, Henry. Denmark-hill, Camberwell, London, S.
1858. ‡Best, William. Leydon-terrace, Leeds.
1859. ‡Beveridge, Robert, M.B. 20 Union-street, Aberdeen.
1863. ‡Bewick, Thomas John. Allenheads, Carlisle.
*Bickerdike, Rev. John, M.A. St. Mary's Parsonage, Leeds.
Bickersteth, Robert. Rodney-street, Liverpool.
1863. ‡Bigger, Benjamin. Gateshead, Durham.
1864. ‡Biggs, Robert. 17 Charles-street, Bath.
1855. ‡Billings, Robert William. 4 St. Mary's-road, Canonbury, London, N.
Bilton, Rev. William, M.A., F.G.S. United University Club, Suffolk-street, London, S.W.; and Chislehurst, Kent.
1842. Binney, Edward William, F.R.S., F.G.S. 40 Cross-street, Manchester.
Birchall, Edwin. College-house, Bradford.
Birchall, Henry. Scarsdale-villas, Kensington, London, W.
1854. ‡Bird, William Smith. Dingle Priory, near Liverpool.
1865. ‡Birkenhead, Edward Hasketh, D.Sc., F.G.S., Royal Infirmary School of Medicine, Liverpool.
Birkenshaw, John Cass.
1862. §Birkin, Richard. Aspley Hall, Nottingham.
1866. *Birkin, Richard, jun. The Park, Nottingham.
**Birks, Rev. Thomas Rawson.*
1842. *Birley, Richard. Seedley, Pendleton, Manchester.
1861. ‡Birley, Thomas Thornely. Highfield, Heaton Mersey, Manchester.
1841. *Birt, William Radcliff, F.R.A.S. Cynthia-villa, Clarendon-road, Walthamstow, London, N.E.
1854. ‡*Bishop, Rev. Francis.*
1866. ‡Bishop, Thomas. Bramcote, Nottingham.
1863. ‡Black, William. South Shields.
Blackburn, Bewicke.
Blackburne, Right Hon. Francis. 34 Merrion-square South, Dublin.
Blackburne, Rev. John, M.A. Yarmouth, Isle of Wight.
Blackburne, Rev. John, jun., M.A. Rectory, Horton, near Chippenham.
1859. ‡Blackie, John Stewart, Professor of Greek. Edinburgh.
1855. *Blackie, W. G., Ph.D., F.R.G.S. 10 Kew-terrace, Glasgow.
*Blackwall, John, F.L.S. Hendre House, near Llanrwst, Denbighshire.
1863. ‡Bladen, Charles. Jarrow Iron Company, Newcastle-on-Tyne.
1859. ‡Blaikie, Sir Thomas. Kingseat, Aberdeen.
1863. ‡Blake, C. Carter, F.G.S. Anthropological Society, 4 St. Martin's-place, Trafalgar-square, London, W.C.
1849. *Blake, Henry Wollaston, M.A., F.R.S. 8 Devonshire-place, Portland-place, London, W.

Year of Election.

1846. *Blake, William. South Petherton, Ilminster.
1865. *Blakeley, Captain. Blakeley Ordnance Company, Bear-lane, Southwark, London.
1845. ‡Blakesley, Rev. J. W., B.D. Ware Vicarage, Hertfordshire.
1861. §Blakiston, Matthew. Mobberley, Knutsford.
*Blakiston, Peyton, M.D., F.R.S. St. Leonard's-on-Sea.
Blanshard, William. Redcar.
Blore, Edward, F.S.A. 4 Manchester-square, London, W.
1853. ‡Blundell, Henry J. P. Brunswick House, Beverley-road, Hull.
1859. ‡Blunt, Sir Charles, Bart. Heathfield Park, Sussex.
Blunt, Henry. Shrewsbury.
1859. ‡Blunt, Capt. Richard. Bretlands, Chertsey, Surrey.
Blyth, B. Hall. 135 George-street, Edinburgh.
1850. ‡Blyth, John, M.D., Professor of Chemistry in Queen's College, Cork.
1858. *Blythe, William. Holland Bank, Church, near Accrington.
Boase, C. W. Royal Bank, Dundee.
1845. ‡Bodmer, Rodolphe. Newport, Monmouthshire.
1864. ‡Bogg, J. Louth, Lincolnshire.
1866. §Bogg, Thomas Wemyss. Louth, Lincolnshire.
1859. *Bohn, Henry G., F.L.S., F.R.A.S., F.R.G.S. York-street, Covent Garden, London, W.C.
*Boileau, Sir John Peter, Bart., F.R.S. 20 Upper Brook-street, London, W.; and Ketteringham Hall, Norfolk.
1859. ‡Bolster, Rev. Prebendary John A. Cork.
Bolton, R. L. Gambier-terrace, Liverpool.
1849. ‡Bolton, Thomas. Hyde House, near Stourbridge.
1866. ‡Bond, Banks. Low Pavement, Nottingham.
1863. ‡Bond, Francis T., M.D. Hartley Institution, Southampton.
Bond, Henry John Hayes, M.D. Cambridge.
Bonomi, Ignatius. 36 Blandford-square, London, N.W.
Bonomi, Joseph. Soane's Museum, 15 Lincoln's-Inn-fields, London, W.C.
1866. ‡Booker, W. H. Cromwell-terrace, Nottingham.
1861. §Booth, James. Castlemere, Rochdale.
1835. ‡Booth, Rev. James, LL.D., F.R.S., F.R.A.S. The Vicarage, Stone, near Aylesbury.
1861. *Booth, John. Monton, near Manchester.
1861. *Booth, Councillor William. Dawson-street, Manchester.
1861. *Borchardt, Dr. Louis. Bloomsbury, Oxford-road, Manchester.
1849. ‡Boreham, William W., F.R.A.S. Haverhill, Suffolk.
1863. ‡Borries, Theodore. Lovaine-crescent, Newcastle-on-Tyne.
*Bossey, Francis, M.D. Oxford-terrace, Red Hill, Surrey.
Bosworth, Rev. Joseph, LL.D., F.R.S., F.S.A., M.R.I.A., Professor of Anglo-Saxon in the University of Oxford. Oxford.
1859. ‡Bothwell, George B. 9 Bon Accord-square, Aberdeen.
1867. §Botley, William, F.S.A. Salisbury Villa, Upper Norwood, London, S.
1858. ‡Botterill, John. Burley, near Leeds.
Bottomley, William. Forbreda, Belfast.
1850. ‡Bouch, Thomas, C.E. 1 South Hanover-street, Edinburgh.
Bourne, Lieut.-Colonel J. D. Heathfield, Liverpool.
1866. §Bourne, Stephen. Hudstone-drive, Harrow, London, N.W.
1858. ‡Bousfield, Charles. Roundhay, near Leeds.
1867. §Bower, Dr. John. Perth.
1846. *Bowerbank, James Scott, LL.D., F.R.S., F.R.A.S. 2 East Ascent, St. Leonard's.
1856. *Bowlby, Miss F. E. 27 Lansdown-crescent, Cheltenham.
1866. *Bowman, E. Victoria Park, Manchester.
1863. ‡Bowman, R. Benson. Newcastle-on-Tyne.

Year of Election.

Bowman, William, F.R.S. 5 Clifford-street, London, W.
‡Bowring, Sir John, LL.D., F.R.S. Athenæum Club, Pall Mall, London, S.W.; and Claremont, Exeter.
1863. ‡Bowron, James. South Stockton-on-Tees.
1863. §Boyd, Edward Fenwick. Moor House, near Durham.
Boyle, Alexander, M.R.I.A. 35 College Green, Dublin.
1865. ‡Boyle, Rev. G. D. Soho House, Handsworth, Birmingham.
Brabant, R. H., M.D. Bath.
Bracebridge, Charles Holt, F.R.G.S. The Hall, Atherstone, Warwickshire.
1849. ‡Bracey, Charles. Birmingham.
1864. §Bradbury, Thomas. Longroyde, Brighouse.
Bradshaw, Rev. John.
1861. *Bradshaw, William. Mosley-street, Manchester.
1842. *Brady, Antonio. Maryland Point, Essex.
1857. *Brady, Cheyne, M.R.I.A. Four Courts, Co. Dublin.
Brady, Daniel F., M.D. 5 Gardiner's Row, Dublin.
1863. ‡Brady, George S. 22 Fawcett-street, Sunderland.
1862. §Brady, Henry Bowman, F.L.S., F.G.S. 40 Mosley-street, Newcastle-on-Tyne.
1858. ‡Brae, Andrew Edmund. 29 Park-square, Leeds.
1864. §Braham, P. 6 George-street, Bath.
1864. §Braikenridge, Rev. George Weare, M.A., F.L.S. Clevedon, Somerset.
*Brakenridge, John. Wakefield.
1865. §Bramwell, F. J. 37 Great George-street, London, S.W.
Brancker, Rev. Thomas, M.A. Limington, Somerset.
1850. ‡Brand, William, F.R.S.E. 5 Northumberland-street, Edinburgh.
1867. §Brand, William. Milnefield, Dundee.
1861. *Brandreth, Henry. Worthing.
Brandreth, John Moss. Preston, Lancashire.
1852. ‡Brazier, James S. Professor of Chemistry in Marischal College and University of Aberdeen.
1857. ‡Brazill, Thomas. 12 Holles-street, Dublin.
1859. ‡Brebner, Alexander C. Audit Office, Somerset House, London, W.C.
1859. *Brebner, James. 20 Albyn-place, Aberdeen.
1867. §Brechin, The Right Rev. Alexander Penrose Forbes, Lord Bishop of, D.C.L. Castlehill, Dundee.
1860. ‡Brett, G. Salford.
1854. *Brett, John Watkins. 2 Hanover-square, London, W.
1866. ‡Brettell, Thomas (Mine Agent). Dudley.
1854. ‡*Brewin, Robert.*
1865. §Brewin, William. Cirencester.
1859. ‡Brewster, Rev. Henry. Manse of Farnell.
1867. §Bridgman, W. Kenceley. Norwich
1866. *Briggs, Arthur. Rawdon, near Leeds.
*Briggs, General John, F.R.S., M.R.A.S., F.G.S. 2 Tenterden-street, London, W.
1866. §Briggs, Joseph. Ulverstone, Lancashire.
1863. *Bright, Sir Charles Tilston, C.E., F.R.G.S., F.R.A.S. 69 Lancaster Gate, W.; and 1 Victoria-street, London, S.W.
Bright, John, M.P. Rochdale, Lancashire.
1863. ‡Brivit, Henri. Washington Chemical Works, Washington, Durham.
1842. Broadbent, Thomas. Marsden-square, Manchester.
1848. ‡Brock, G. B. Bryn Tyfi, Swansea.
1859. ‡Brodhurst, Bernard Edwin. 20 Grosvenor-street, Grosvenor-square, London, W.
1847. ‡Brodie, Sir Benjamin C., Bart., M.A., F.R.S., Professor of Chemistry in the University of Oxford. Cowley House, Oxford.

Year of Election.

1834. ‡Brodie, Rev. James. Monimail, Fifeshire.
1865. ‡Brodie, Rev. Peter Bellenger, M.A., F.G.S. Rowington Vicarage, near Warwick.
1867. §*Brodie, William. Edinburgh.*
1853. ‡Bromby, J. H., M.A. The Charter House, Hull.
Bromilow, Henry G.
1842. Brook, William. Meltham, York.
*Brooke, Charles, M.A., F.R.S. 16 Fitzroy-square, London, W.
1855. ‡Brooke, Edward. Marsden House, Stockport, Cheshire.
1864. *Brooke, Rev. J. T. Bannerdown House, Batheaston, Bath.
1855. ‡Brooke, Peter William. Marsden House, Stockport, Cheshire.
1863. §Brooks, John C. Wallsend, Newcastle-on-Tyne.
*Brooks, Samuel. King-street, Manchester.
1846. *Brooks, Thomas (Messrs. Butterworth and Brooks). Manchester.
Brooks, William. Ordfall-hill, East Retford, Nottinghamshire.
1847. ‡Broome, C. E. Elmhurst, Batheaston, near Bath.
1863. *Brough, Lionel H., F.G.S., one of Her Majesty's Inspectors of Coal-Mines. 38 Cornwallis Crescent, Clifton, Bristol.
1867. §Brough, J. C. Norman-terrace, Stockwell, London, S.
*Broun, John Allan, F.R.S., Astronomer to His Highness the Rajah of Travancore.
1863. ‡Brown, Alexander Crum, F.R.S.E. Arthur Lodge, Dalkeith-road, Edinburgh.
Brown, Charles Edward. Cambridge.
1867. §Brown, Charles Gage, M.D. 88 Sloane-street, London, S.W.
1855. ‡Brown, Colin. 3 Mansfield-place, Glasgow.
1863. *Brown, Rev. Dixon. Unthank Hall, Haltwhistle, Carlisle.
1858. ‡Brown, Alderman Henry. Bradford.
1865. §Brown, Edwin, F.G.S. Burton-upon-Trent.
Brown, Hugh. Broadstone, Ayrshire.
1858. ‡Brown, John. Barnsley.
1859. ‡Brown, John Crombie, LL.D., F.L.S., Professor of Botany in South African College, Cape Town.
1863. ‡Brown, John H. 29 Sandhill, Newcastle-on-Tyne.
1863. ‡Brown, Ralph. Lambton's Bank, Newcastle-on-Tyne.
1856. *Brown, Samuel, F.S.S. The Elms, Larkhall Rise, Clapham, London, S.
*Brown, Thomas. Mainder Park, Newport, Monmouthshire.
*Brown, William. 3 Maitland Park Villas, Haverstock-hill, London.
1855. ‡Brown, William. 179 Bath-street, Glasgow.
1850. ‡Brown, William, F.R.S.E. 25 Dublin-street, Edinburgh.
1865. ‡Brown, William. 41 *a* New-street, Birmingham.
1863. ‡Browne, B. Chapman. Tynemouth.
1854. ‡*Browne, Henry, M.D.*
1866. *Browne, Rev. J. H. Lowdham, Nottingham.
1862. *Browne, Robert Clayton, B.A. Browne's Hill, Carlow, Ireland.
Browne, William. Richmond-hill, near Liverpool.
1865. §Browne, William. The Friary, Lichfield.
1865. §Browning, John. 111 Minories, London, E.
1855. §Brownlee, James, Jun. 173 St. George's-road, Glasgow.
Brownlie, Archibald. Glasgow.
1853. ‡Brownlow, William B. Villa-place, Hull.
*Bruce, Alexander John. Kilmarnock.
1852. ‡Bruce, Rev. William. Belfast.
1851. ‡Bruff, P. Handford Lodge, Ipswich.
1863. *Brunel, H. M. Duke-street, Westminster, London, S.W.
1863. ‡Brunel, J. Duke-street, Westminster, London, S.W.
1859. ‡*Bryant, Arthur C.*

Year of Election.

1858. ‡*Bryant, Wilberforce.*
1861. §Bryce, James. York Place, Higher Broughton, Manchester.
Bryce, James, M.A., LL.D., F.R.S.E., F.G.S. High School, Glasgow.
Bryce, Rev. R. J., LL.D., Principal of Belfast Academy. Belfast.
1850. ‡Bryson, Alexander, F.R.S.E. Hawkhill, Edinburgh.
1859. ‡Bryson, William Gillespie. Cullen, Aberdeen.
1867. §Buccleuch and Queensberry, His Grace the Duke of, K.B., D.C.L., F.R.S. (President). 37 Grosvenor-square, London, S.W.; and Dalkeith Palace, Edinburgh.
1867. §Buchan, Thomas. Strawberry Bank, Dundee.
Buchanan, Andrew, M.D., Regius Professor of the Institutes of Medicine in the University of Glasgow. Glasgow.
Buchanan, Archibald. Catrine, Ayrshire.
Buchanan, D. C. Poulton cum Seacombe, Cheshire.
1850. ‡*Buchanan George.*
Buchanan, James, R.E.
*Buck, George Watson. Ramsay, Isle of Man.
1864. §Buckle, Rev. George, M.A. Twerton Vicarage, Bath.
1846. ‡Buckley, Colonel. New Hall, Salisbury.
1865. *Buckley. Henry. Church-road, Edgbaston. Birmingham.
1847. ‡Buckley, Rev. W. E., M.A. Middleton Cheney, Banbury.
1848. *Buckman, James, F.L.S., F.G.S., Professor of Natural History in the Royal Agricultural College, Cirencester. Bradford Abbas, Sherbourne, Dorsetshire.
1851. *Buckton, G. Bowdler, F.R.S. Weycombe, Haslemere, Surrey.
1848. ‡Budd, Edward. Hafod Works, Swansea.
1848. *Budd, James Palmer. Ystalyfera Iron Works, Swansea.
1851. ‡Bullen, George. Carr-street, Ipswich.
1845. ‡Bunbury, Sir Charles James Fox, Bart., F.R.S., F.L.S., F.G.S., F.R.G.S. Barton Hall, Bury St. Edmunds.
1845. ‡Bunbury, Edward H., F.G.S. 15 Jermyn-street, London, S.W.
1865. ‡Bunce, John Mackray. 'Journal Office,' New-street, Birmingham.
Bunch, Rev. Robert James, B.D. Emanuel Rectory, Loughborough.
1863. §Bunning, T. Wood. 34 Grey-street, Newcastle-on-Tyne.
Bunt, Thomas G. Nugent-place, Bristol.
1854. ‡Burckhardt, Otte. Bank Chambers, Liverpool.
1842. *Burd, John. 37 Jewin-street, Aldersgate-street, London, E.C.
1863. *Burgess, John. Rastrick, Yorkshire.
Burgoyne, General Sir John F., Bart., G.C.B., D.C.L., F.R.S., Inspector General of Fortifications. 8 Gloucester-gardens, London, W.
1857. ‡Burk, J. Lardner, LL.D. 2 North Great George-street, Dublin.
1865. ‡Burke, Luke. 5 Albert-terrace, Acton, London, W.
1859. ‡Burnett, Newell. Belmont-street, Aberdeen.
1860. ‡Burrows, Montague, M.A., Commander R.N. Oxford.
1866. *Burton, Frederick M. Highfield, Gainsborough.
1857. ‡Busby, John. 9 Trafalgar-terrace, Monkstown, Ireland.
1864. ‡Bush, W. 7 Circus, Bath.
Bushell, Christopher. Royal Assurance-buildings, Liverpool.
1855. *Busk, George, F.R.S., Sec. L.S., F.G.S., Examiner in Comparative Anatomy in the University of London. 42 Harley-street, Cavendish-square, London, W.
1857. ‡Butt, Isaac, Q.C. 4 Henrietta-street, Dublin.
1845. ‡Butterfield, J. M. 45 Mount, York.
1861. *Butterworth, John. 58 Mosley-street, Manchester.
1855. *Buttery, Alexander W. Monkland Iron and Steel Company, Cardarroch, near Airdrie.

Year of Election.

1845. ‡*Button, Charles.*
Buxton, Edward North.
1854. ‡Byerley, Isaac. Seacombe, Liverpool.
Byng, William Bateman. Orwell Works House, Ipswich.
1852. ‡Byrne, Rev. Jas. Ergenagh Rectory, Omagh, Armagh.

Cabbell, Benjamin Bond, M.A., F.R.S., F.S.A., F.R.G.S. 1 Brick-court, Temple, E.C.; and 52 Portland-place, London, W.
Cabbell, George.
1854. ‡*Cadell, William.*
1858. §Cail, John. Stokesley, Yorkshire.
1863. ‡Cail, Richard. The Fell, Gateshead.
1854. ‡Caine, Nathaniel. Dutton-street, Liverpool.
1858. *Caine, Rev. William, M.A. Ducie-grove, Oxford-road, Manchester.
1863. ‡Caird, Edward. Finnart, Dumbartonshire.
1861. *Caird, James Key. Finnart on Loch Long, by Gare Loch Head, Dumbartonshire.
1855. *Caird, James T. Greenock.
1857. ‡Cairnes, Professor. Queen's College, Galway.
1845. ‡Calder, Rev. William. Fairfield Parsonage, Liverpool.
Caldwell, Robert. 9 Bachelor's-walk, Dublin.
1857. ‡Callan, Rev. N. J., Professor of Natural Philosophy in Maynooth College.
1842. Callender, W. R. The Elms, Didsbury, Manchester.
1853. ‡Calver, E. K., R.N. 21 Norfolk-street, Sunderland.
1857. ‡Cameron, Charles A., M.D. 17 Ely-place, Dublin.
Cameron, John. Glasgow.
1859. ‡Campbell, Rev. C. P., Principal of King's College, Aberdeen. Aberdeen.
1857. *Campbell, Dugald, F.C.S. 7 Quality-court, Chancery-lane, London, E.C.
1855. ‡Campbell, Dugald, M.D. 186 Sauchiehall-street, Glasgow.
Campbell, Sir Hugh P. H., Bart. 10 Hill-street, Berkeley-square, London, W.; and Marchmont House, near Dunse, Berwickshire.
*Campbell, Sir James. Glasgow.
Campbell, Rev. James, D.D. Forkhill, Dundalk, Ireland.
1855. ‡*Campbell, John.*
Campbell, John Archibald, F.R.S.E. Albyn-place, Edinburgh.
1852. ‡Campbell, William. Donegal-square West, Belfast.
1859. ‡Campbell, William. Dunmore, Argyllshire.
1862. *Campion, Rev. William. Queen's College, Cambridge.
1853. ‡Camps, William, M.D., F.L.S., F.R.G.S. 40 Park-street, Grosvenor-square, London, W.
Cape, Rev. Joseph, M.A., F.C.P.S. Birdbrook Rectory, Halstead, Essex.
*Carew, William Henry Pole. Antony House, near Devonport.
1861. ‡Carlton, James. Mosley-street, Manchester.
1867. §Carmichael, David (Engineer). Dundee.
1867. §Carmichael, George. 11 Dudhope-terrace, Dundee.
Carmichael, H. 18 Hume-street, Dublin.
Carmichael, John T. C. Messrs. Todd & Co., Cork.
*Carpenter, Philip Pearsall, B.A., Ph.D. Montreal, Canada.
1854. ‡Carpenter, Rev. R. Lant, B.A. Halifax.
1845. ‡Carpenter, William B., M.D., F.R.S., F.L.S., F.G.S., Registrar of the University of London. 56 Regent's Park Road, London, N.W.
1849. ‡Carr, William. Gomersal, Leeds.
1842. *Carr, William, M.D., F.R.C.S. Lee Grove, Blackheath, London, S.E.
1855. ‡*Carrick, John.*

Year of Election.

1861. *Carrick, Thomas. 37 Princess-street, Manchester.
1867. §Carruthers, William, F.L.S. British Museum, London, W.C.
1861. *Carson, Rev. Joseph, D.D., M.R.I.A. 18 Fitzwilliam-place, Dublin.
1857. ‡Carte, Alexander, M.D. Royal Dublin Society, Dublin.
1845. ‡Carter, G. B. Lord-street, Liverpool.
1866. §Carter, H. H. The Park, Nottingham.
1855. ‡Carter, Richard, C.E. Long Carr, Barnsley, Yorkshire.
*Cartmell, Rev. James, D.D., F.G.S., Master of Christ's College. Cambridge.
Cartmell, Joseph, M.D. Carlisle.
Cartwright, Rev. R. B.
1862. ‡Carulla, Facundo, F.A.S.L. Care of Messrs. Daglish and Co., 8 Harrington-street, Liverpool.
1866. §Casella, L. P., F.R.A.S. South Grove, Highgate, London, N.
1842. *Cassels, Rev. Andrew, M.A. Batley Vicarage, near Leeds.
Castle, Charles. Clifton, Bristol.
1853. ‡Cator, John B., Commander R.N. 1 Adelaide-street, Hull.
1855. ‡*Catterill, Rev. Henry.*
1859. ‡Catto, Robert. 44 King-street, Aberdeen.
1866. §Catton, Alfred R., M.A., F.R.S.E. The University, Edinburgh.
1849. ‡Cawley, Charles Edward. The Heath, Kirsall, Manchester.
1860. §Cayley, Arthur, F.R.S., V.P.R.A.S., Sadlerian Professor of Mathematics in the University of Cambridge. Cambridge.
Cayley, Digby. Brompton, near Scarborough.
Cayley, Edward Stillingfleet. Wydale, Malton, Yorkshire.
1858. *Chadwick, Charles, M.D. 35 Park-square, Leeds.
1860. ‡Chadwick, David. 64 Cross-street, Manchester.
1842. Chadwick, Edwin, C.B. Richmond, Surrey.
1842. Chadwick, Elias, M.A. Pudleston-court, near Leominster.
1842. Chadwick, John. Broadfield, Rochdale.
1859. ‡Chadwick, Robert. Highbank, Manchester.
1861. ‡Chadwick, Thomas. Wilmslow Grange, Cheshire.
*Challis, Rev. James, M.A., F.R.S., F.R.A.S., Plumian Professor of Astronomy in the University of Cambridge. 13 Trumpington-street, Cambridge.
1859. ‡Chalmers, John Inglis. Aldbar, Aberdeen.
1859. ‡Chalmers, Rev. Dr. P. Dunfermline.
1865. ‡Chamberlain, J. H. Christ Church-buildings, Birmingham.
1842. Chambers, George. High Green, Sheffield.
Chambers, John. Ridgefield, Manchester.
*Chambers, Robert, F.R.S.E., F.L.S., F.G.S. 17 Hereford-square, Mayfair, London, W.
*Champney, Henry Nelson. St. Paul's-square, York.
1865. ‡Chance, A. M. Edgbaston, Birmingham.
1865. *Chance, James Simmers. Brown's Green, Handsworth, Birmingham.
1865. §Chance, Robert Lucas. Chad Hill, Edgbaston, Birmingham.
1861. *Chapman, Edward. Frewen Hall, Oxford.
1850. ‡Chapman, Prof. E. J. University College; and 4 Addison-terrace, Kensington, London, W.
1866. ‡Chapman, Ernest T. Hope Cottage, Hanwell, London, W.
1861. *Chapman, John. Hill End, Mottram, Manchester.
Chapman, Captain John James, R.A., F.R.G.S. Adelaide-square, Bedford.
1866. ‡Chapman, William. The Park, Nottingham.
1854. ‡Chapple, Frederick. Canning-street, Liverpool.
1836. Charlesworth, Edward, F.G.S. Whittington Club, Arundel-street, London, W.C.
1863. ‡Charlton, Edward, M.D. 7 Eldon-square, Newcastle-on-Tyne.

Year of Election.

1863. ‡*Charlton, F.*
1866. ‡Charnock, Richard Stephen, Ph.D., F.S.A., F.R.G.S. 8 Gray's Inn-square, London, W.C.
Chatto, W. J. P. Union Club, Trafalgar-square, London, W.C.
1867. *Chatwood, Samuel. 2 Wentworth-place, Bolton.
1864. ‡Cheadle, W. B., M.A., M.D., F.R.G.S. 6 Hyde Park-place, Cumberland Gate, London, W.
1842. *Cheetham, David. Weston Park, Bath.
1852. ‡Cheshire, Edward. Conservative Club, London, S.W.
Cheshire, John.
1853. *Chesney, Major-General Francis Rawdon, R.A., D.C.L., F.R.S., F.R.G.S. Ballyardle, Kilkeel, Co. Down, Ireland.
*Chevallier, Rev. Temple, B.D., F.R.A.S., Professor of Mathematics and Astronomy in the University of Durham.
*Chichester, Ashhurst Turner Gilbert, D.D., Lord Bishop of. 31 Queen Anne-street, Cavendish-square, London, W.; and The Palace, Chichester.
1865. ‡Child, Gilbert W., M.D. Oxford.
1842. *Chiswell, Thomas. 2 Lincoln-grove, Plymouth-grove, Manchester.
1863. §Cholmeley, Rev. C. H. Magdalen College, Oxford.
1859. ‡Christie, John, M.D. 46 School-hill, Aberdeen.
1861. ‡Christie, Professor R. C., M.A. 7 St. James's-square, Manchester.
Christison, Robert, M.D., F.R.S.E., Professor of Dietetics, Materia Medica, and Pharmacy in the University of Edinburgh. Edinburgh.
1860. ‡Church, William Selby, M.A. 1 Harcourt Buildings, Temple, London, E.C.
1850. ‡Churchill, The Right Hon. Lord Alfred. Blenheim, Woodstock.
1857. ‡Churchill, F., M.D. 15 Stephen's Green, Dublin.
1863. ‡Clapham, A. 3 Oxford-street, Newcastle-on-Tyne.
1863. ‡Clapham, Henry. 5 Summerhill-grove, Newcastle-on-Tyne.
1855. §Clapham, Robert Calvert. Wincomblee, Walker, Newcastle-on-Tyne.
1858. ‡Clapham, Samuel. 17 Park-place, Leeds.
1857. ‡Clarendon, Frederick Villiers. 11 Blessington-street, Dublin.
*Clark, Rev. Charles, M.A. Queen's College, Cambridge.
Clark, Courtney K. Haugh End, Halifax.
1859. ‡Clark, David. Coupar Angus, Fifeshire.
* *Clark, Francis.*
Clark, G. T. Bombay; and Athenæum Club, London, S.W.
1846. *Clark, Henry, M.D. 4 Upper Moira-place, Southampton.
Clark, Sir James, Bart., M.D., M.A., F.R.S., F.R.G.S., Physician in Ordinary to the Queen. Bagshot Park, Surrey.
1861. ‡Clark, Latimer. 1 Victoria-street, Westminster, London, S.W.
1855. ‡Clark, Rev. William, M.A. Barrhead, near Glasgow.
Clark, William, M.D., F.R.S., F.G.S. Cambridge.
1865. ‡Clarke, Rev. Charles. Charlotte-road, Edgbaston, Birmingham.
Clarke, George. Mosley-street, Manchester.
1861. *Clarke, J. H. Newton Villa, Newton-le-Willows, near Warrington.
1842. Clarke, Joseph. Waddington Glebe, Lincoln.
1851. ‡Clarke, Joshua, F.L.S. Fairycroft, Saffron Walden.
Clarke, Thomas, M.A. Knedlington Manor, Howden, Yorkshire.
1861. ‡Clay, Charles, M.D. 101 Piccadilly, Manchester.
*Clay, Joseph Travis, F.G.S. Rastrick, Yorkshire.
1854. ‡Clay, Robert. St. Ann-street, Liverpool.
1855. ‡*Clay, William.*
1856. *Clay, William. 4 Park-hill-road, Liverpool.
1866. ‡Clayden, Rev. P. W. Clarendon-street, Nottingham.

Year of Election.

1857. *Clayton, David Shaw. Norbury, Stockport, Cheshire.
1850. ‡Cleghorn, Hugh, M.D. Madras Establishment.
1859. ‡Cleghorn, John. Wick.
1861. §Cleland, Professor John, M.D. Queen's College, Galway.
1857. ‡Clements, Henry. Dromin, Listowel, Ireland.
‡Clerk, Rev. D. M. Deverill, Warminster, Wiltshire.
Clerke, Rev. C. C., D.D., Archdeacon of Oxford and Canon of Christ Church, Oxford. Milton Rectory, Abingdon, Berkshire.
1850. ‡*Clerke, Right Honourable Sir George, Bart.*
1852. ‡Clibborn, Edward. Royal Irish Academy, Dublin.
1865. ‡Clift, John E., C.E. Redditch, Bromsgrove.
1861. *Clifton, Professor R. B., M.A. Oxford.
1849. ‡Clive, R. H. Hewell, Bromsgrove.
Clonbrock, Lord Robert. Clonbrock, Galway.
1854. ‡Close, The Very Rev. Francis, M.A. Carlisle.
1866. §Close, Thomas. St. James's-street, Nottingham.
Clough, Rev. Alfred B., B.D. Brandeston, Northamptonshire.
1859. ‡Clouston, Rev. Charles. Sandwick, Orkney.
1861. *Clouston, Peter. Glasgow.
1863. §Clutterbuck, Thomas. Warkworth, Acklington.
1855. *Coats, Peter. Woodside, Paisley.
1855. *Coats, Thomas. Fergeslie House, Paisley.
Cobb, Edward. South Bank, Weston, near Bath.
1851. *Cobbold, John Chevallier, M.P. Tower-street, Ipswich; and Athenæum Club, London, S.W.
1864. §Cobbold, T. Spencer, M.D., F.R.S., F.L.S., Lecturer on Comparative Anatomy at the Middlesex Hospital. 84 Wimpole-street, Cavendish-square, London, W.
1845. ‡Cocker, John, M.A. Cambridge.
*Cocker, Jonathan. Higher Broughton, Manchester.
1854. ‡Cockey, William. 38 Burnbank Gardens, Glasgow.
1861. *Coe, Rev. Charles C. Leicester.
1864. *Cochrane, James Henry. Dunkathel, Glanmire, Co. Cork.
1865. ‡Coghill, H. Newcastle-under-Lyme.
1853. ‡Colchester, William, F.G.S. Grundesburgh Hall, Ipswich.
1859. ‡Cole, Edward. 11 Hyde Park-square, London, W.
1859. *Cole, Henry Warwick. 3 New-square, Lincoln's Inn, London, W.C.
1860. ‡Coleman, J. J., F.C.S. North Wales Coal Oil Co., Leeswood-hill, near Mold.
1854. *Colfox, William, B A. Bridport, Dorsetshire.
1857. ‡Colles, William, M.D. 21 Stephen's Green, Dublin.
1861. *Collie, Alexander. 12 Kensington Palace-gardens, London, W.
1861. ‡*Collinge, John.*
1854. ‡Collingwood, Cuthbert, M.A., M.B., F.L.S. 14 Gloucester-place, Greenwich, London, S.E.
1861. *Collingwood, J. Frederick, F.G.S. 54 Gloucester-street, Belgrave-road, Pimlico, London, S.W.
1865. *Collins, James Tertius. 36 Cumberland-street, Birmingham.
1849. ‡Collins, Joseph. Frederick-street, Edgbaston, Birmingham.
Collins, Robert, M.R.D.S. Ardsallagh, Navan, Ireland.
Collis, Stephen Edward. Listowel, Ireland.
Colthurst, John. Clifton, Bristol.
1865. *Combe, Thomas, M.A. Oxford.
*Compton, Lord Alwyn. Castle Ashby, Northamptonshire.
1846. *Compton, Lord William. 145 Piccadilly, London, W.
1852. ‡Connal, Michael. 16 Lynedock-terrace, Glasgow.
1853. ‡*Constable, Sir T. C., Bart.*
1858. ‡Conybeare, Henry, F.G.S. 20 Duke-street, Westminster, London.

Year of Election.

1864. *Conwell, Eugene Alfred, M.R.I.A. Trim, Ireland.
1859. ‡Cook, E. R. Stamford-hill, London, N.
1861. **Cook, Henry.*
Cooke, Captain Adolphous.
**Cooke, A. B.*
1863. ‡Cooke, Edward William, F.R.S., F.L.S., F.G.S., A.R.A. The Ferns, Hyde Park-gate, South Kensington, London, S.W.
Cooke, James R., M.A. 73 Blessington-street, Dublin.
1854. ‡Cooke, John. Howe Villa, Richmond, Yorkshire.
Cooke, J. B. Exchange-buildings, Liverpool.
Cooke, Rev. T. L., M.A. Magdalen College, Oxford.
1854. ‡Cooke, Rev. William, M.A. Gazeley Vicarage, near Newmarket.
Cooke, William Fothergill. Telegraph Office, Lothbury, London, E.C.
1859. *Cooke, William Henry, M.A., F.S.A. Elm-court, Temple, London, E.C.
1865. ‡Cooksey, Joseph. West Bromwich, Birmingham.
1862. *Cookson, Rev. H. W., D.D. St. Peter's College, Cambridge.
1863. ‡Cookson, N. C. Benwell Tower, Newcastle-on-Tyne.
1850. ‡Cooper, Sir Henry, M.D. 7 Charlotte-street, Hull.
Cooper, James. 55 Pembroke Villas, Bayswater, London, W.
1846. ‡Cooper, William White. 19 Berkeley-square, London, W.
1865. §Cope, James. Pensnett, near Dudley.
1856. ‡Copeland, George F., F.G.S., 5 Bay's-hill Villas, Cheltenham.
1854. ‡Copland, James, M.D., F.R.S. 5 Old Burlington-street, London, W.
Copland, William, F.R.S.E. Dumfries.
1863. ‡Coppin, John. North Shields.
1842. *Corbet, Richard. Hadington-hill, Oxford.
1842. Corbett, Edward. Ravenoak, Cheadle-hulme, Cheshire.
1855. ‡Corbett, Joseph Henry, M.D., Professor of Anatomy and Physiology, Queen's College, Cork.
Cormack, John Rose, M.D., F.R.S.E. 5 Bedford-square, London, W.C.
1860. ‡*Corner, C. Tinsley.*
Cory, Rev. Robert, B.D., F.C.P.S. Stanground, Peterborough.
Cottam, George. 2 Winsley-street, London, W.
1857. ‡Cottam, Samuel. Brazennose-street, Manchester.
Cotter, John.
1864. §Cotton, General Frederick C. Knolton Hall, Ruabon.
**Cotton, Rev. William Charles, M.A. New Zealand.*
Couper, James. 12 Royal Exchange-square, Glasgow.
1865. §Courtald, Samuel. Gosfield Hall, Essex.
*Courtney, Henry, M.R.I.A. 24 Fitzwilliam-place, Dublin.
Cowan, John. Valleyfield, Pennycuick, Edinburgh.
1863. ‡Cowan, John A. Blaydon Burn, Durham.
1863. ‡Cowan, Joseph, jun. Blaydon, Durham.
Cowie, Rev. Benjamin Morgan, M.A. 42 Upper Harley-street, Cavendish-square, London, W.
1860. ‡Cowper, Edward Alfred, M.I.C.E. 6 Great George-street, Westminster, London, S.W.
1867. *Cox, Edward. Clement Park, Dundee.
1867. *Cox, George Addison. Beechwood, Dundee.
1867. §Cox, James. Clement Park, Dundee.
1850. ‡Cox, John. Georgie Mills, Edinburgh.
Cox, Robert. 26 Rutland-street, Edinburgh.
1867. *Cox, Thomas Hunter. Duncarse, Dundee.
1866. §Cox, William. 50 Newhall-street, Birmingham.
1867. §Cox, William. Foggley, Lochee, by Dundee.
1847. ‡Cox, Rev. W. H., B.D. Eaton Bishop, Herefordshire.

Year of
Election.

1854. §Crace-Calvert, Frederick, Ph.D., F.R.S., F.C.S., Honorary Professor of Chemistry to the Manchester Royal Institution. Royal Institute, Manchester.
Craig, J. T. Gibson, F.R.S.E. Edinburgh.
1859. ‡Craig, S. Clayhill, Enfield, Middlesex.
1857. ‡Crampton, Rev. Josiah., M.R.I.A. The Rectory, Florence-court, Co. Fermanagh, Ireland.
1858. ‡Cranage, Edward, Ph.D. The Old Hall, Wellington, Shropshire.
Craven, Robert.
1852. ‡Crawford, Alexander, jun. Mount Prospect, Belfast.
1857. ‡*Crawford, George Arthur, M.A.*
1849. ‡Crawfurd, John, F.R.S., F.R.G.S. 4 Elvaston-place, Kensington, W.; and Athenæum Club, Pall Mall, London, S.W.
1842. *Crewdson, Thomas D. Dacca Mills, Manchester.
Creyke, The Venerable Archdeacon. Beeford Rectory, Driffield.
*Crichton, William. 1 West India-street, Glasgow.
1854. ‡*Crisp, M. F.*
1865. ‡Crocker, Edwin, F.C.S. Seymour Villa, 76 Hungerford Road, Holloway, London, N.
Croft, Rev. John, M.A., F.C.P.S.
1858. ‡Crofts, John. Hillary-place, Leeds.
Croker, Charles Phillips, M.D., M.R.I.A. 7 Merrion-square West, Dublin.
1859. ‡Croll, A. A. 10 Coleman-street, London, E.C.
1857. ‡Crolly, Rev. George. Maynooth College, Ireland.
1855. ‡Crompton, Charles, M.A. 22 Hyde Park-square, London, W.
*Crompton, Rev. Joseph, M.A. Norwich.
1866. ‡Cronin, William. 4 Brunel-terrace, Nottingham.
Crook, J. Taylor.
Crook, William Henry, LL.D.
1865. §Crookes, William, F.R.S., F.C.S. 20 Mornington-road, Regent's Park, London, N.W.
1855. *Cropper, Rev. John. Stand, near Manchester.
1859. ‡Crosfield, John. Rothay Bank, Ambleside.
1861. ‡Cross, Rev. John Edward, M.A. Appleby Vicarage, near Brigg.
1867. §Crosskey, Rev. Henry W. The Geological Society of Glasgow, Glasgow.
1853. ‡Crosskill, William, C.E. Beverley, Yorkshire.
1866. *Crossley, Louis J., F.M.S. Willow Hall, near Halifax.
1865. §Crotch, George Robert. 8 Pearl-street, Cambridge.
1854. ‡Crowe, John. 3 Mersey Chambers, Liverpool.
1861. §Crowley, Henry. 255 Cheetham-hill-road, Manchester.
1863. §Crowther, Benjamin. Wakefield.
1863. ‡Cruddas, George. Elswick Engine Works, Newcastle-on-Tyne.
1860. ‡Cruickshank, John. City of Glasgow Bank, Aberdeen.
1859. ‡Cruickshank, Provost. Macduff, Aberdeen.
1859. ‡Crum, James. Busby, Glasgow.
1849. ‡Cubitt, Thomas. Thames Bank, Pimlico, London, S.W.
1851. ‡Cull, Richard, F.S.A., F.R.G.S. 13 Tavistock-street, Bedford-square, London, W.C.
Culley, Robert. Bank of Ireland, Dublin.
1859. ‡Cumming, Sir A. P. Gordon, Bart. Altyre.
1847. ‡*Cumming, Rev. J. G., M.A.*
1861. *Cunliffe, Edward Thomas. Handforth, Manchester.
1861. *Cunliffe, Peter Gibson. Handforth, Manchester.
1850. ‡Cunningham, James. 50 Queen-street, Edinburgh.
1861. ‡Cunningham, James, F.R.S.E. Queen-street, Edinburgh.
Cunningham, John.

Year of Election.

1852. ‡Cunningham, John. Macedon, near Belfast.
1850. ‡Cunningham, Rev. William, D.D. 17 Salisbury-road, Edinburgh.
1855. §Cunningham, William A. Manchester and Liverpool District Bank, Manchester.
1850. ‡Cunningham, Rev. W. B. Prestonpans, Scotland.
1866. ‡Cunnington, John. 68 Oakley-square, Bedford New Town, London, N.W.
1867. *Cursetjee, Manockjee, F.R.S.A., Judge of Bombay. Villa-Byculla, Bombay.
1857. ‡Curtis, Professor Arthur Hill, LL.D. 6 Trinity College, Dublin.
1866. ‡Cusins, Rev. F. L. 26 Addison-street, Nottingham.
1834. *Cuthbert, J. R. 40 Chapel-street, Liverpool.
Cuthbertson, Allan. Glasgow.

1863. ‡Daglish, John. Hetton, Durham.
1854. ‡Daglish, Robert, C.E. Orrell Cottage, near Wigan.
1854. ‡Daglish, Robert, jun. St. Helen's, Lancashire.
1863. ‡Dale, J. B. South Shields.
1853. ‡Dale, Rev. P. Steele, M.A. Hollingfare, Warrington.
1865. ‡Dale, Rev. R. W. 12 Calthorpe-street, Birmingham.
1867. §Dalgleish, Dr. O. Newport, Dundee.
1867. §Dalgleish, W. Dundee.
Dalmahoy, James, F.R.S.E. 9 Forres-street, Edinburgh.
1850. ‡Dalmahoy, Patrick. 69 Queen-street, Edinburgh.
1859. ‡Dalrymple, Charles Elphinstone. West Hall, Aberdeenshire.
1859. ‡Dalrymple, Colonel. Troup, Scotland.
1867. *Dalrymple, Donald, M.D., F.R.G.S. Thorpe Lodge, Norwich.
Dalton, Edward, LL.D., F.S.A. Dunkirk House, Nailsworth.
*Dalton, Rev. James Edward, B.D. Seagrave, Loughborough.
1859. ‡*Daly, Lieut.-Colonel H. D.*
1859. *Dalzell, Allen, M.D. The University, Edinburgh.
Dalziel, John, M.D. Holm of Drumlanrig, Thornhill, Dumfriesshire.
1862. ‡Danby, T. W. Downing College, Cambridge.
1859. ‡Dancer, J. B., F.R.A.S. Old Manor House, Ardwick, Manchester.
1847. ‡*Danson, John Towne.*
1849. *Danson, Joseph, F.C.S. 6 Shaw-street, Liverpool.
Danson, William. 6 Shaw-street, Liverpool.
1859. §Darbishire, Charles James. Rivington, near Chorley, Lancashire.
1861. *Darbishire, Robert Dukinfield, B.A., F.G.S. 21 Brown-street, Manchester.
*Darbishire, Samuel D. Pendyffryn, near Conway.
1852. ‡*Darby, Rev. Jonathan L.*
Darwin, Charles R., M.A., F.R.S., F.L.S., F.G.S. Down, near Bromley, Kent.
1854. ‡*Dashwood, Charles.*
1848. §Da Silva, Johnson. Burntwood, Wandsworth Common, London, S.W.
1859. ‡Daun, Robert, M.D., F.G.S., Deputy Inspector-General of Hospitals. The Priory, Aberdeen.
Davey, Richard, M.P., F.G.S. Redruth, Cornwall.
1859. ‡Davidson, Charles. Grove House, Auchmull, Aberdeen.
1859. ‡Davidson, Patrick. Inchmarlo, near Aberdeen.
1847. ‡*Davidson, Rev. Samuel, LL.D.*
1863. ‡Davies, Griffith. 17 Cloudesley-street, Islington, London, N.
Davies, John Birt, M.D. The Laurels, Edgbaston, Birmingham.
1842. Davies, Dr. Thomas. Chester.
1864. §Davis, Charles E., F.S.A. 55 Pulteney-street, Bath.
Davis, Rev. David, B.A. Lancaster.

Year of Election.

1856. *Davis, Sir John Francis, Bart., K.C.B., F.R.S., F.R.G.S. Athenæum Club, London, S.W.; and Hollywood, Compton Greenfield, near Bristol.
1859. ‡Davis, J. Barnard, M.D., F.S.A. Shelton, Staffordshire.
1859. *Davis, Richard, F.L.S. 9 St. Helen's-place, London, E.C.
1863. *Davison, Joseph. Greencroft, Durham.
1864. §Davison, Richard. Great Driffield, Yorkshire.
1857. ‡Davy, Edmund W., M.D. Kimmage Lodge, Roundtown, near Dublin.
1854. *Dawbarn, William. 3 Temple, Dale-street, Liverpool.
1859. ‡*Dawes, Captain (Adjutant R.A. Highlanders).*
Dawes, John Samuel, F.G.S. Smethwick House, near Birmingham.
1860. *Dawes, John T., jun. Smethwick House, near Birmingham.
1864. ‡Dawkins, W. Boyd, B.A., F.G.S. Upminster, Romford, Essex.
*Dawson, Christopher H. Low Moor, Bradford, Yorkshire.
1865. ‡Dawson, George, M.A. Shenstone, Lichfield.
*Dawson, Henry. 14 St. James's-road, Liverpool.
1855. ‡Dawson, J. W., LL.D., F.R.S., Principal of M'Gill College, Montreal, Canada.
Dawson, John. Royds Hall, Bradford, Yorkshire.
Dawson, Thomas.
1859. *Dawson, William G. Plumstead Common, Kent.
1865. ‡Day, Edward Charles H. Charmouth, Dorset.
1861. ‡Deacon, Henry. Runcorn Gap, Cheshire.
1859. ‡Dean, David. Banchory, Aberdeen.
1861. ‡Dean, Henry. Colne, Lancashire.
1854. §Deane, Henry, F.L.S. Clapham Common, London, S.
*Deane, Sir Thomas. Kingstown, Co. Dublin.
1866. ‡Debus, H. The College, Clifton.
1851. ‡De Grey, The Hon. F. Copdock, Ipswich.
*De Grey and Ripon, George Frederick, Earl, F.R.S. 1 Carlton-gardens, London, S.W.
1854. *De la Rue, Warren, Ph.D., F.R.S., Pres. C.S., F.R.A.S. Cranford, Middlesex; and 110 Bunhill-row, London, E.C.
Denchar, John. Morningside, Edinburgh.
1854. ‡Denison, The Hon. William. Grinston, Tadcaster.
Denison, Sir William Thomas, K.C.B., Col. R.E., F.R.S., F.R.G.S., East Brent, Weston-super-Mare, Somerset.
1847. ‡*Dennis, J. C., F.R.A.S.*
*Dent, Joseph. Ribston Hall, Wetherby.
Dent, William Yerbury. Royal Arsenal, Woolwich, S.E.
De Saumarez, Rev. Havilland, M.A. St. Peter's Rectory, Northampton.
De Tabley, George, Lord, F.Z.S. Tabley House, Knutsford, Cheshire.
*Devonshire, William, Duke of, K.G., M.A., LL.D., F.R.S., F.G.S., F.R.G.S., Chancellor of the University of Cambridge. Devonshire House, Piccadilly, London, W.; and Chatsworth, Derbyshire.
1859. ‡Dewar, Rev. D., D.D., LL.D., Principal of Marischal College, Aberdeen.
1858. ‡Dibb, Thomas Townend. Little Woodhouse, Leeds.
1850. ‡Dick, Professor William. Veterinary College, Edinburgh.
1854. ‡Dicker, J. R. 29 Exchange-alley North, Liverpool.
1852. ‡Dickie, G., M.D., Professor of Natural History in Queen's College, Belfast.
1864. *Dickinson, F. H. Wingweston, Somerton, Taunton.
1863. ‡Dickinson, G. T. Claremont-place, Newcastle-on-Tyne.
1853. *Dickinson, Joseph, M.D., F.R.S. 92 Bedford-street South, Liverpool.
1861. *Dickinson, W. L. 1 St. James's-street, Manchester.
1867. §Dickson, Alexander, M.D. Trinity College, Dublin.

Year of Election.

1848. ‡Dickson, Peter. 28 Upper Brook-street, London, W.
1863. *Dickson, William, Clerk of the Peace for Northumberland. Alnwick, Northumberland.
*Dikes, William Hey, F.G.S. Wakefield.
*Dilke, Sir C. Wentworth, Bart., M.P., F.L.S., F.G.S., F.R.G.S. 76 Sloane-street, London, S.W.
1862. *Dilke, Charles Wentworth. 76 Sloane Street, London, S.W.
1848. ‡Dillwyn, Lewis Llewelyn, M.P., F.L.S., F.G.S. Parkwern, near Swansea.
1859. *Dingle, Rev. J. Lanchester, Durham.
1837. Dircks, Henry, C.E., F.C.S. 48 Charing Cross, London, S.W.
1853. ‡Dixon, Edward, M.Inst.C.E. Wilton House, Southampton.
1854. ‡Dixon, Hugh. Devonshire House, Birkenhead.
1865. ‡Dixon, L. Hooton, Cheshire.
1858. ‡*Dixon, Isaiah.*
Dixon, Rev. W. H. Bishopthorpe, near York.
1861. ‡Dixon, W. Hepworth, F.S.A., F.R.G.S. Essex-villas, Queen's-road, St. John's-wood, London, N.W.
1859. ‡*Dixon, William Smith.*
*Dobbin, Leonard, jun., M.R.I.A. 27 Gardiner's-place, Dublin.
1851. ‡Dobbin, Orlando T., LL.D., M.R.I.A. Ballivor, Kells, Co. Meath.
1860. ‡Dobbs, Archibald Edward. Balliol College, Oxford.
1864. *Dobson, William. Oakwood, Bathwick-hill, Bath.
Dockray, Benjamin. Lancaster.
1857. ‡Dodds, Thomas W., C.E. Rotherham.
*Dodsworth, Benjamin. St. Leonard's-place, York.
*Dodsworth, George. Clifton-grove, near York.
Dolphin, John. Delves House, Berry Edge, near Gateshead.
1851. ‡Domvile, William C., F.Z.S. Thorn-hill, Bray, Dublin.
1867. §Don, John. The Lodge, Broughty Ferry, by Dundee.
1867. §Don, William G. St. Margaret's, Broughty Ferry, by Dundee.
*Donisthorpe, George Edmund. Holly Bank, Moortown, Leeds.
1860. ‡Donkin, William Fishburn, M.A., F.R.S., F.R.A.S., Savilian Professor of Astronomy in the University of Oxford. 34 Broad-street, Oxford.
1861. ‡Donnelly, Captain, R.E. South Kensington Museum, London, W.
1857. *Donnelly, William, C.B., Registrar-General for Ireland. Auburn, Malahide, Ireland.
1857. ‡Donovan, M., M.R.I.A. Clare-street, Dublin.
1863. ‡Doubleday, Thomas. 25 Ridley-place, Newcastle-upon-Tyne.
1867. §Dougall, Andrew Maitland, R.N. Scotscraig, Tayport, Fifeshire.
1863. *Doughty, C. Montagu. 5 Gloucester-place, Portman-sq., London, W.
1855. §Dove, Hector, F.G.S. Rose Cottage, Trinity, near Edinburgh.
Downall, Rev. John. Okehampton, Devon.
1857. ‡Downing, S., LL.D., Professor of Civil Engineering in the University of Dublin. Dublin.
1865. *Dowson, E. Theodore. Geldestone, near Beccles, Suffolk.
1852. ‡Drennan, Dr. Chichester-street, Belfast.
Drennan, William, M.R.I.A. 35 North Cumberland-street, Dublin.
1865. ‡Drew, Robert A. 6 Stanley-place, Duke-street, Broughton, Manchester.
Drummond, David.
Drummond, H. Home, F.R.S.E. Blair Drummond, Stirling.
1858. ‡Drummond, James. Greenock.
1859. ‡Drummond, Robert. 17 Stratton-street, London, W.
1866. *Dry, Thomas. 12 Gloucester-road, Regent's Park, London, N.W.
1863. ‡Dryden, James. South Benwell, Northumberland.
1856. *Ducie, Henry John Reynolds Moreton, Earl of, F.R.S. 1 Belgrave-square, London, S.W.; and Tortworth-court, Wotton-under-Edge.

Year of Election.

1835. ‡*Duckett, Joseph F.*
1846. ‡Duckworth, William. Beechwood, near Southampton.
1867. *Duff, Mounstuart Ephinstone Grant-, LL.B., M.P. Athenæum Club, Pall Mall, London, S.W.; and Eden, near Banff, N. B.
1852. ‡Dufferin, The Rt. Hon. Lord. Highgate, London, N.; and Clandeboye, Belfast.
1859. *Duncan, Alexander. Rhode Island, United States.
1859. ‡Duncan, Charles. 52 Union-place, Aberdeen.
*Duncan, James, M.D. Farnham House, Finglass, Co. Dublin.
1866. *Duncan, James. 9 Mincing-lane, London, E.C.
1861. ‡*Duncan, James.*
‡*Duncan, John W.*
Duncan, J. F., M.D. 19 Gardiner's-place, Dublin.
1867. §Duncan, Peter Martin, M.B., F.G.S. Lee, London, S.E.
Duncan, W. Henry, M.D.
Dundas, Major-General Robert.
Dunlop, Alexander. Clober, Milngavie, near Glasgow.
1853. *Dunlop, William Henry. Annan-hill, Kilmarnock.
1865. §Dunn, David. Annet House, Skelmorlie, by Greenock, N.B.
1862. §Dunn, Robert, F.R.C.S. 31 Norfolk-street, Strand, London W.C.
Dunnington-Jefferson, Rev. Joseph, M.A., F.C.P.S. Thicket Hall, York.
1857. ‡Du Noyer, George V. 51 Stephen's Green, Dublin.
*Dunraven, Edwin, Earl of, F.R.S., F.R.A.S., F.G.S., F.R.G.S. Adare Manor, Co. Limerick; and Dunraven Castle, Glamorganshire.
1859. ‡Duns, Rev. John, F.R.S.E. Torphichan, Bathgate, N. B.
1852. ‡Dunville, William. Richmond Lodge, Belfast.
1849. ‡Duppa, Duppa. Church Stretton, Shropshire.
1866. ‡Duprey, Perry. Woodbury Down, Stoke Newington, London, N.
1860. ‡Durham, Arthur Edward, F.R.C.S., F.L.S., Demonstrator of Anatomy, Guy's Hospital, London, S.E.
Durnford, Rev. R. Middleton, Lancashire.
1851. ‡Durrant, C. M., M.D. Rushmere, Ipswich.
1857. ‡Dwyer, Henry L., M.A., M.B. 67 Upper Sackville-street, Dublin.
Dykes, Robert. Kilmorie, Torquay, Devon.

1861. ‡Eadson, Richard. 13 Hyde-road, Manchester.
1864. ‡Earle, Rev. A. Rectory, Monkton Farleigh, Bath.
Earle, Charles, F.G.S.
*Earnshaw, Rev. Samuel, M.A. Broomfield, Sheffield.
1863. §Easton, James. Nest House, near Gateshead, Durham
Eaton, Rev. George, M.A. The Pole, Northwich.
Ebden, Rev. James Collett, M.A., F.R.A.S. Great Stukeley Vicarage, Huntingdonshire.
1867. §Eckersley, James. Leith Walk, Edinburgh.
1861. ‡Ecroyd, William Farrer. Spring Cottage, near Burnley.
*Eddison, Edwin. Headingley-hill, Leeds.
1858. *Eddison, Francis. North Laiths, Ollerton, Newark.
*Eddy, James R., F.G.S. Carleton Grange, Skipton.
Eden, Thomas. Riversdale-road, Aigburth, Liverpool.
1852. ‡*Edgar, Rev. —, D.D.*
1861. ‡Edge, John William. Percy-street, Hulme, Manchester.
*Edgeworth, Michael P., F.L.S., F.R.A.S. Mastrim House, Anerley, London, S.
1855. ‡*Edington, Thomas.*
1855. ‡Edmiston, Robert. Elmbank-crescent, Glasgow.
1859. ‡Edmond, James. Cardens Haugh, Aberdeen.
1867. *Edward, Allan. Farington Hall, Dundee.

Year of Election.

1867. §Edward, Charles. Springfield, Dundee.
1867. §Edward, James. Balruddery, Dundee.
Edwards, James, B.A.
Edwards, John. Halifax.
1855. *Edwards, J. Baker, Ph.D. Royal Institution Laboratory, Liverpool.
1867. §Edwards, William. Dundee.
*Egerton, Sir Philip de Malpas Grey, Bart., M.P., F.R.S., F.G.S. Oulton Park, Tarporley, Cheshire.
Egginton, Samuel Hall. North Ferriby, Yorkshire.
1859. *Eisdale, David A., M.A. 38 Dublin-street, Edinburgh.
1854. ‡Elcum, Charles Frederick. 3 Crescent-terrace, Cheltenham.
1855. ‡Elder, David. 19 Paterson-street, Glasgow.
1858. ‡Elder, John. Elm Park, Govan Road, Glasgow.
Ellacombe, Rev. H. T., F.S.A. Bitton, near Bristol.
1863. ‡Ellenberger, J. L. Worksop.
1855. §Elliot, Robert. Wolflee, Hawick, N. B.
1861. *Elliot, Sir Walter, K.S.I., F.L.S. Wolflee, Hawick, N. B.
1864. ‡Elliott, E. B. Washington, United States.
1862. §Elliott, Frederick Henry, M.A. 449 Strand, London, W.C.
Elliott, John Fogg. Elvet-hill, Durham.
1859. ‡Ellis, Henry S., F.R.A.S. Fair Park, Exeter.
1857. ‡Ellis, Hercules. Lisnaroc, Clones, Ireland.
1864. *Ellis, Alexander John, B.A., F.R.S. 25 Argyll-road, Kensington, London, W.
1864. *Ellis, Joseph. Brighton.
1864. §Ellis, J. W. High House, Thornwaite, Ripley, Yorkshire.
*Ellis, Rev. Robert, A.M. Grimstone House, near Malton, Yorkshire.
Ellman, Rev. E. B. Berwick Rectory, near Lewes, Sussex.
1862. ‡Elphinstone, H. W., M.A., F.L.S. Cadogan-place, London, S.W.
Eltoft, William. Care of J. Thompson, Esq., 30 New Cannon-street, Manchester.
1856. ‡*Elwait, Mons., LL.D.*
1863. ‡Embleton, Dennis, M.D. Northumberland-street, Newcastle-on-Tyne
1863. ‡Emery, Rev. W., B.D. Corpus Christi College, Cambridge.
1858. ‡Empson, Christopher. Headingley, near Leeds.
1866. ‡Enfield, Richard. Low Pavement, Nottingham.
1866. §Enfield, William. Low Pavement, Nottingham.
1853. ‡English, Edgar Wilkins. Yorkshire Banking Company, Lowgate, Hull.
Enniskillen, William Willoughby, Earl of, D.C.L., F.R.S., M.R.I.A., F.G.S. 32A Mount-street, Grosvenor-square, London, S.W.; and Florence Court, Fermanagh, Ireland.
*Enys, John Samuel, F.G.S. Enys, Cornwall.
*Erle, Rev. Christopher, M.A., F.G.S. Hardwick Rectory, near Aylesbury.
1864. *Eskrigge, R. A. 24 Albany, Old Hall-street, Liverpool.
1862. *Esson, William, M.A. Ness House, Cheltenham.
Estcourt, Rev. W. J. B. Long Newton, Tetbury.
Eustace, John, M.D.
1865. *Evans, Rev. Charles, M.A. King Edward's School, New-street, Birmingham.
1854. ‡Evans, Edward. Rock Ferry, Liverpool.
1849. *Evans, George Fabian, M.D. Waterloo-street, Birmingham.
1848. §Evans, Griffith F. D., M.D. Trewern, near Welshpool, Montgomeryshire.
1861. *Evans, John, F.R.S., F.S.A., F.G.S. Nash Mills, Hemel Hempstead.
1865. ‡Evans, Sebastian, M.A. Highgate, near Birmingham.
1866. ‡Evans, Thomas. Belper, Derbyshire.
1865. *Evans, William. Chad-road, Edgbaston, Birmingham.

Year of Election.

Evanson, R. T., M.D. Holme Hurst, Torquay.
1854. ‡Everest, A. M. Robert. 11 Reform Club, London, S.W.
1863. *Everitt, George Allen, F.R.G.S., Belgian Consul. Oakfield, Moseley, near Birmingham.
Ewart, William, M.P. 6 Cambridge-square, London, W.; and Broadlands, Devizes.
1859. *Ewing, Archibald Orr. Clermont House, Glasgow.
1855. *Ewing, William. 209 West George-street, Glasgow.
1846. *Eyre, George Edward, F.G.S., F.R.G.S. 59 Lowndes-square, Knightsbridge, London; and Warren's, near Lyndhurst, Hants.
1866. §Eyre, Major-General Sir Vincent, F.R.G.S. Athenæum Club, Pall Mall, London, S.W.
Eyton, Charles. Hendred House, Abingdon.
1849. ‡Eyton, T. C. Eyton, near Wellington, Salop.

1842. Fairbairn, Thomas. Manchester.
*Fairbairn, William, C.E., LL.D., F.R.S., F.R.G.S. Manchester.
1866. ‡Fairbank, F. R., M.A. St. Mary's-terrace, Hulme, Manchester.
1865. ‡Fairley, Thomas. Medical School, Leeds.
1864. ‡Falkner, F. H. Lyncombe, Bath.
Fannin, John, M.A. 41 Grafton-street, Dublin.
1859. ‡Farquharson, Robert O. Houghton, Aberdeen.
1861. §Farr, William, M.D., D.C.L., F.R.S., Superintendent of the Statistical Department General Registry Office, London. Southlands, Bickley, Kent.
1866. *Farrar, Rev. Frederick William, M.A., F.R.S. Harrow.
1857. ‡Farrelly, Rev. Thomas. Royal College, Maynooth.
1859. *Faulkner, Charles, F.S.A., F.G.S., F.R.G.S. Museum, Deddington, Oxon.
1859. *Fawcett, Henry, M.P., Professor of Political Economy in the University of Cambridge. Trinity Hall, Cambridge.
1854. ‡*Fawcett, John.*
1863. ‡Fawcus, George. Alma-place, North Shields.
1833. Fearon, John Peter. Cuckfield, Sussex.
1845. ‡Felkin, William, F.L.S. The Park, Nottingham.
Fell, John B. Ulverston, Lancashire.
1864. §Fellowes, Frank P. 8 The Green, Hampstead, London, N.W.
1852. ‡Fenton, Samuel Greame. 9 College-square, Belfast; and Keswick, near Belfast.
1855. ‡Ferguson, James. Gas Coal-works, Lesmahago, Glasgow.
1859. ‡Ferguson, John. Cove, Nigg, Inverness.
1855. ‡*Ferguson, Peter.*
1867. §*Ferguson, Robert M. Edinburgh.*
1857. ‡Ferguson, Samuel. 20 North Great George-street, Dublin.
1854. ‡Ferguson, William, F.L.S., F.G.S. 2 St. Aiden's-terrace, Birkenhead.
1867. *Fergusson, H. B. Blackness-terrace, Dundee.
1863. *Fernie, John. Clarence Iron Works, Leeds.
Ferrall, J. M., M.D., M.R.I.A. 35 Rutland-square, Dublin.
1862. ‡Ferrers, Rev. N. M., M.A. Caius College, Cambridge.
Ferrier, Alexander James. 69 Leeson-street, Dublin.
Field, Edwin W. 36 Lincoln's Inn Fields, London, W.C.
Fielding, G. H., M.D. Tunbridge, Kent.
1854. ‡Fielding, James. Mearclough Mill, Sowerby Bridge, near Halifax.
1864. ‡Finch, Frederick, George, B.A., F.G.S. Blackheath Park, London.
Finch, John. Bridge Work, Chepstow.
Finch, John, jun. Bridge Work, Chepstow.
1859. ‡Findlay, Alexander George, F.R.G.S. 53 Fleet-street, London, E.C.; and Hayes, Kent.

Year of Election.

1863. ‡Finney, Samuel. Sheriff-hill Hall, Newcastle-upon-Tyne.
Firth, Thomas. Northwick.
1854. ‡*Fischel, Rev. Arnold, D.D.*
1851. *Fischer, William L. F., M.A., Professor of Natural Philosophy in the University of St. Andrews, Scotland.
1858. ‡Fishbourne, Captain E. G., R.N. 6 Welamere-terrace, Paddington, London, W.
Fisher, Rev. John Hutton, M.A., F.G.S., F.C.P.S. Kirkby Lonsdale, Westmoreland.
1858. ‡Fishwick, Captain Henry. Carr-hill, Rochdale.
1857. ‡Fitzgerald, The Right Hon. Lord Otho, M.P. 13 Dominick-street, Dublin.
1857. ‡Fitzpatrick, Thomas, M.D. 31 Lower Bagot-street, Dublin.
Fitzwilliam, Hon. George Wentworth, M.P., F.R.G.S. 19 Grosvenor-square, London, S.W.; and Wentworth House, Rotherham.
1865. ‡Fleetwood, D. J. 45 George Street, St. Paul's, Birmingham.
Fleetwood, Sir Peter Hesketh, Bart. Rossall Hall, Fleetwood, Lancashire.
1850. ‡Fleming, Professor Alexander, M.D. 20 Temple Row, Birmingham.
Fleming, Christopher, M.D. Merrion-square North, Dublin.
1842. *Fleming, John, M.A.*
1855. ‡*Fleming, John.*
Fleming, John G., M.D. 155 Bath-street, Glasgow.
*Fleming, William, M.D. Rowton Grange, near Chester.
1867. §Fletcher, Alfred E. Whiston, near Prescot.
1853. ‡Fletcher, Isaac, F.R.S., F.R.A.S. Tarn Bank, Workington.
Fletcher, T. B. E., M.D. 7 Waterloo-street, Birmingham.
Flood, Rev. James Charles.
1862. ‡Flower, William Henry, F.R.S., F.L.S., F.G.S., F.R.C.S. Royal College of Surgeons, Lincoln's Inn-fields, London, W.C.
1866. ‡Flowers, J. W. Park Hill, Croydon, Surrey.
1867. §Foggie, William. Woodville, Maryfield, Dundee.
1854. *Forbes, David, F.R.S., F.G.S. 12 York-place, Portman-square, London, W.
Forbes, George, F.R.S.E.
*Forbes, James David, LL.D., F.R.S. L. & E., F.G.S., Principal of the United Colleges of St. Salvator and St. Leonards, St. Andrews. Pitlochrie.
1855. ‡Forbes, Rev. John. Symington Manse, Biggar, Scotland.
1855. ‡Forbes, Rev. John, D.D. 150 West Regent-street, Glasgow.
Forbes, Sir John Stuart, Bart., F.R.S.E. Fettercairne House, Kincardineshire.
Ford, H. R. Morecombe Lodge, Yealand Congers, Lancashire.
1866. ‡Ford, William. Hartsdown Villa, Kensington Park Gardens East, London, W.
*Forrest, William Hutton. Stirling.
1867. §Forster, Anthony. Wood Close, Grasmere, Windermere.
1849. *Forster, Thomas Emerson. 7 Ellison-place, Newcastle-upon-Tyne.
*Forster, William. Ballynure, Clones, Ireland.
1858. ‡Forster, William Edward. Burley, Otley, near Leeds.
1854. *Fort, Richard, F.G.S. Read Hall, Whalley, Lancashire.
1865. ‡Foster, Balthazar W., M.D., F.L.S. 4 Old Square, Birmingham.
1865. *Foster, Clement Le Neve, D.Sc., F.G.S. Royal Institution, Truro.
1845. ‡Foster, Ebenezer. The Elms, Cambridge.
1857. *Foster, George C., B.A., F.C.S., Professor of Experimental Physics in University College, London, W.C.
*Foster, Rev. John, M.A. The Oaks Parsonage, Loughborough.
1845. ‡Foster, John N. St. Andrews, Biggleswade.
1859. *Foster, Michael, M.D. University College, London, W.C.

Year of Election.

1859. §Foster, Peter Le Neve, M.A. Society of Arts, Adelphi, London, W.C.
1863. ‡Foster, Robert. 30 Rye-hill, Newcastle-upon-Tyne.
1859. *Foster, S. Lloyd. Old Park Hall, Walsall, Staffordshire.
1842. *Fothergill, Benjamin.*
1866. §Fowler, George. Ashby-de-la-Zouch.
1856. ‡Fowler, Rev. Hugh, M.A. College-gardens, Gloucester.
1859. ‡Fowler, Rev. J. C., LL.D., F.A.S. Scotl. The Manse, Ratho, by Edinburgh.
*Fowler, Robert. Rahinstown, Co. Meath, Ireland.
Fox, Alfred. Falmouth.
1842. *Fox, Charles. Trebah, Falmouth.
*Fox, Rev. Edward, M.A. The Vicarage, Romford, Essex.
*Fox, Joseph Hayland. Wellington, Somerset.
1860. ‡Fox, Joseph John. Church-row, Stoke Newington, London, N.
*Fox, Robert Barclay. Falmouth.
Fox, Robert Were, F.R.S. Falmouth.
1866. **Francis, G. B. London.*
1848. ‡Francis, George Grant, F.S.A. Burrows Lodge, Swansea.
Francis, William, Ph.D., F.L.S., F.G.S., F.R.A.S. Red Lion-court, Fleet-street, London, E.C.; and 1 Matson Villas, Marsh-gate, Richmond, Surrey.
1846. ‡Frankland, Edward, Ph.D., F.R.S., Professor of Chemistry in the Royal Institution and St. Bartholomew's Hospital. 42 St. John's Park-road, Haverstock-hill, London. N.W.
*Frankland, Rev. Marmaduke Charles. Chowbent, near Manchester.
Franks, Rev. J. C., M.A. Whittlesea, near Peterborough.
1859. ‡Fraser, George B. 3 Airlie-place, Dundee.
Fraser, James. 25 Westland-row, Dublin.
Fraser, James William. 8A Kensington Palace-gardens, London, W.
1865. *Fraser, John, M.A., M.D. Chapel Ash, Wolverhampton.
1859. *Frazer, Daniel. 113 Buchanan-street, Glasgow.
1860. ‡Freeborn, Richard Fernandez. 38 Broad-street, Oxford.
1847. *Freeland, Humphrey William, F.G.S. The Athenæum Club, Pall Mall, London, S.W.
1865. §Freeman, James. 15 Francis-road, Edgbaston, Birmingham.
1855. ‡*Frere, Captain, R.A.*
Frere, George Edward, F.R.S. Royden Hall, Diss, Norfolk.
1856. *Frerichs, John Andrew. 1 Keynsham Bank, Cheltenham.
Fripp, George D., M.D. Barnfield Hill, Southampton.
1857. *Frith, Richard Hastings, C.E. 51 Leinster-road, Rathmines, Dublin.
1863. *Frith, William. Burley Wood, near Leeds.
Frost, Charles, F.S.A. Hull.
1847. ‡Frost, William, F.R.A.S. Wentworth Lodge, Upper Tulse-street, London, S.
1860. *Froude, William. Emsleigh Paignton, Torquay.
Fry, Francis. Cotham, Bristol.
Fry, Richard. Cotham, Bristol.
Fry, Robert. Tockington, Gloucestershire.
1863. ‡Fryar, Mark. Eaton Moor Colliery, Newcastle-on-Tyne.
*Fullarton, Allan. 19 Woodside-place, Glasgow.
1859. ‡Fuller, Frederick, M.A., Professor of Mathematics in University and King's College, Aberdeen.
1852. ‡Furguson, Professor John C., M.A., M.B. Queen's College, Belfast.
Furlong, Rev. Thomas, M.A. 10 Sydney-place, Bath.
1864. *Furneaux, Rev. A. St. Germain's Parsonage, Cornwall.

*Gadesden, Augustus William, F.S.A. Leigh House, Lower Tooting, Surrey.

Year of Election.

1854. ‡*Gage, M. A., C.E.*
1857. ‡Gages, Alphonse, M.R.I.A. Museum of Irish Industry, Dublin.
1863. *Gainsford, W. D. Darnall Hall, Sheffield.
1850. ‡Gairdner, W. F., M.D. 18 Hill-street, Edinburgh.
1861. ‡Galbraith, Andrew. Glasgow.
Galbraith, Rev. J. A., M.R.I.A. Trinity College, Dublin.
1867. §Gale, James M. 33 Miller-street, Glasgow.
1863. ‡Gale, Samuel, F.C.S. 338 Oxford-street, London, W.
1861. ‡Galloway, Charles John. Knott Mill Iron Works, Manchester.
1859. ‡*Galloway, James. Calcutta.*
1861. ‡Galloway, John, jun. Knott Mill Iron Works, Manchester.
Galloway, S. H. Linbach, Austria.
1860. *Galton, Captain Douglas, C.B., R.E., F.R.S., F.G.S., F.R.G.S. 12 Chester-street, Grosvenor-place, London, S.W.
1860. *Galton, Francis, F.R.S., F.G.S., F.R.G.S. (*General Secretary.*) 42 Rutland-gate, Knightsbridge, London, S.W.
1842. Gardiner, Lot. Bradford, Yorkshire.
1862. §Garner, Robert, F.L.S. Stoke-upon-Trent.
1865. §Garner, Mrs. Robert. Stoke-upon-Trent.
1842. Garnett, Jeremiah. Warren-street, Manchester.
1852. ‡Garret, James R. Holywood, Belfast.
1854. ‡Garston, Edgar. Aigburth, Liverpool.
1847. *Gaskell, Samuel. 19 Whitehall-place, London, S.W.
1842. Gaskell, Rev. William, M.A. Plymouth-grove, Manchester.
1846. §Gassiot, John Peter, F.R.S., F.C.S. Clapham Common, London, S.
1862. *Gatty, Charles Henry, M.A., F.L.S., F.G.S. Felbridge Park, East Grinsted, Sussex.
1859. ‡Geddes, William D., Professor of Greek, King's College, Old Aberdeen.
1854. ‡Gee, Robert, M.D. Oxford-street, Liverpool.
1867. §Geikie, Archibald, F.R.S., F.G.S. Geological Museum, Jermyn-street, London, S.W.; and Ardrossan, Ayrshire.
1855. ‡Gemmell, Andrew. 38 Queen-street, Glasgow.
1855. ‡*Gemmell, Thomas.*
1854. §Gerard, Henry. 13 Rumford-place, Liverpool.
1856. *Gething, George Barkley. Springfield, Newport, Monmouthshire.
Gibb, Duncan. Strand-street, Liverpool.
1863. *Gibb, Sir George Duncan, Bart., M.D., M.A., LL.D., F.G.S. 1 Bryanston street, London, W.; and Falkland, Fife.
Gibbins, Joseph.
Gibbins, Thomas.
1865. ‡Gibbins, William. Battery Works, Digbeth, Birmingham.
Gibson, Edward. Hull.
*Gibson, George Stacey. Saffron Walden.
1852. ‡*Gibson, James.*
1859. ‡Gibson, William Sidney, M.A., F.S.A., F.G.S. Tynemouth.
1867. §Gibson, W. L., M.D. Tay-street, Dundee.
1849. ‡Gifford, Rev. E. H. Birmingham.
1842. Gilbert, Dr. Joseph Henry, F.R.S., F.C.S. Harpenden, near St. Albans.
1861. *Gilbert, James Montgomery. Bowdon, Cheshire.
1857. ‡Gilbert, J. T., M.R.I.A. Blackrock, Dublin.
1859. *Gilchrist, James, M.D. Crichton Royal Institution, Dumfries.
Gilderdale, Rev. John, M.A. Walthamstow, Essex.
Giles, Rev. William. Netherleigh House, near Chester.
1864. §Gill, Thomas (*Local Treasurer*). 4 Sydney-place, Bath.
1850. ‡Gillespie, Alexander, M.D. Edinburgh.
1854. ‡*Gillis, F. L.*

Year of Election.

1849. ‡*Gilpin, Benjamin.*
1861. *Gilroy, George. Hindley House, Wigan.
1867. §Gilroy, Robert. Craigie, by Dundee.
1867. §Ginsburgh. Rev. Dr. C. D. Liverpool.
1850. *Gladstone, George, F.C.S. Clapham Common, London, S.
1849. *Gladstone, John Hall, Ph.D., F.R.S., F.C.S. 17 Pembridge-square, Hyde Park, London, W.
1861. *Gladstone, Murray. Broughton, Manchester.
1852. ‡*Gladstone, Thomas Murray.*
1861. *Glaisher, James, F.R.S., F.R.A.S. 1 Dartmouth-place, Blackheath, Kent.
1853. ‡Gleadon, Thomas Ward. Moira-buildings, Hull.
1859. ‡Glennie, J.S. Stuart. 6 Stone-buildings, Lincoln's Inn, London, W.C.
1867. §Gloag, John A. L. Inverleith-row, Edinburgh.
Glover, George. Ranelagh-road, Pimlico, London, S.W.
1852. ‡Godwin, John. Wood House, Rostrevor, Belfast.
1846. ‡Godwin-Austen, Robert A.C., B.A., F.R.S., F.G.S. Chilworth Manor, Guildford.
Goldsmid, Sir Francis Henry, Bart., M.P. St. John's Lodge, Regent's Park, London, N.W.
1842. *Gooch, Thomas L.*
1857. ‡Good, John. 50 City Quay, Dublin.
1852. ‡Goodbody, Jonathan. Clare, King's County, Ireland.
1842. *Goodman, John, M.D. The Promenade, Southport.
1865. ‡Goodman, J. D. Minories, Birminham.
Goodwin, Very Rev. Harvey, D.D., F.C.P.S., Dean of Ely. Caius College, Cambridge.
1859. ‡*Gordon, H. G.*
*Gordon, Rev. James Crawford, M.A. Delamont, Downpatrick, Downshire.
1857. ‡Gordon, Samuel, M.D. 11 Hume-street, Dublin.
1865. ‡Gore, George, F.R.S. 50 Islington-row, Edgbaston, Birmingham.
*Gotch, Rev. Frederick William, LL.D. Stokes Croft, Bristol.
*Gotch, Thomas Henry. Kettering.
1849. ‡Gough, The Hon. Frederick. Perry Hall, Birmingham.
1857. ‡Gough, The Hon. G. S. Rathronan House, Clonmel.
Gould, John, F.R.S., F.L.S., F.R.G.S., F.Z.S. 26 Charlotte-street, Bedford-square, London, W.C.
1854. ‡*Gourley, Daniel De la C., M.D.*
1867. §Gourley, Henry (Engineer). Dundee.
Gowland, James. London-wall, London, E.C.
1861. ‡Grafton, Frederick W. Park-road, Whalley Range, Manchester.
1867. *Graham, Cyril, F.R.G.S. 9 Cleveland-row, St. James's, London, S.W.
1848. ‡*Graham, John B.*
Graham, Lieutenant David. Mecklewood, Stirlingshire.
*Graham, Thomas, M.A., D.C.L., F.R.S. L. & E., F.G.S., V.P.C.S., Master of the Mint. 4 Gordon-square, London, W.C.
1852. *Grainger, John. Rose Villa, Belfast.
Grainger, Richard. Newcastle-upon-Tyne.
1850. ‡*Grainger, Thomas.*
1859. ‡Grant, Hon. James. Cluny Cottage, Forres.
1855. §Grant, Robert, M.A., F.R.A.S., Regius Professor of Astronomy in the University of Glasgow. The Observatory, Glasgow.
1854. ‡*Grantham, John, C.E.*
1864. ‡Grantham, Richard F. 7 Great Scotland-yard, London, S.W.
1854. ‡Grantham, R. B. 7 Great Scotland-yard, London.
Granville, Augustus Bozzi, M.D., F.R.S., F.G.S., M.R.I.A. 5 Cornwall-terrace, Warwick-square, Pimlico, London, S.W.

Year of Election.

1854. ‡Gravatt, William, F.R.S. 15 Park-street, London, S.W.
*Graves, Rev. Richard Hastings, D.D. Brigown Glebe, Michelstown, Co. Cork.
1864. *Gray, Rev. Charles. Trinity College, Cambridge.
1865. ‡Gray, Charles. Swan-bank, Bilston.
1857. ‡Gray, Sir John, M.D. Rathgar, Dublin.
*Gray, John. Greenock.
*Gray, John Edward, Ph.D., F.R.S., Keeper of the Zoological Collections of the British Museum. British Museum, London, W.C.
1864. ‡Gray, Jonathan. Summerhill-house, Bath.
1859. ‡Gray, Rev. J. H. Bolsover Castle, Derbyshire.
*Gray, William, F.G.S. (*Local Treasurer.*) Minster Yard, York.
1861. *Gray, William, M.P. Darcey Lever Hall, Bolton.
1854. *Grazebrook, Henry, jun. Clent Grove, near Stourbidge, Worcestershire.
1866. §Greaves, Charles A. 13 Wardwick, Derby.
Green, Rev. Henry, M.A. Heathfield, Knutsford, Cheshire.
*Greenaway, Edward. 16 Lansdowne-crescent, London, W.
1858. *Greenhalgh, Thomas. Astley House, Sharples, near Bolton-le-Moors.
1863. ‡Greenwell, G. E. Poynton, Cheshire.
1862. §Greenwood, Henry. Huyton Park, Huxton, near Liverpool.
1849. ‡Greenwood, William. Stones, Todmorden.
1861. *Greg, Robert Philips, F.G.S. (*Local Treasurer.*) Outwood Lodge, near Manchester.
Gregg, T. H. 22 Ironmonger-lane, Cheapside, London, E.C.
1860. ‡Gregor, Rev. Walter, M.A. Pitsligo, Rosehearty, Aberdeenshire.
1861. §Gregson, Samuel Leigh. Aigburth, near Liverpool.
Gresham, Thomas M. Raheny, Dublin.
*Greswell, Rev. Richard, B.D., F.R.S., F.R.G.S. St. Giles's-street, Oxford.
Greville, R. K., LL.D., F.R.S.E. Edinburgh.
Grey, Captain The Hon. Frederick William. Howick, Northumberland.
1866. §Grey, Rev. W. H. C. Nottingham.
1863. ‡Grey, W. S. Norton, Stockton-on-Tees.
1859. ‡Grierson, Thomas Boyle, M.D. Thornhill, Dumfriesshire.
1855. ‡*Griffin, Charles.*
*Griffin, John Joseph, F.C.S. Garrick-street, London, W.C.
Griffin, S. F.
Griffith, Rev. C. T., D.D. Elm, near Frome, Somerset.
1859. *Griffith, George, M.A., F.C.S. (*Assistant General Secretary.*) 1 Woodside, Harrow.
Griffith, George R. Fitzwilliam-place, Dublin.
*Griffith, Sir Richard, Bart., LL.D., F.R.S.E., M.R.I.A., F.G.S. 2 Fitzwilliam-place, Dublin.
1847. ‡Griffith, Thomas. Bradford-street, Birmingham.
Griffith, Walter H., M.A.
Griffiths, Rev. John, M.A. 63 St. Giles's, Oxford.
1842. Grimshaw, Samuel, M.A. Errwod, Buxton.
1864. ‡*Groom-Napier, Charles Ottley. Southwell Cottage, Kingsdown, Bristol.*
Grove, William Robert, Q.C., M.A., Ph.D., F.R.S. 46 Upper Harley-street, W; and 5 Crown Office-row, Temple, London, E.C.
1849. ‡*Grover, Rev. H. M.*
1863. *Groves, Thomas B. 80 St. Mary's-street, Weymouth, Dorset.
1857. ‡Grubb, Thomas, F.R.S., M.R.I.A. Bank of Ireland, Dublin.
Guest, Edwin, LL.D., M.A., F.R.S., F.L.S., F.R.A.S., Master of Caius College, Cambridge. Caius Lodge, Cambridge; and Sandford-park, Oxfordshire.

Year of Election.

1867. §Guild, John. Bayfield, West Ferry, Dundee.
Guinness, Henry. 17 College Green, Dublin.
1842. Guinness, Richard Seymour. 17 College Green, Dublin.
1856. *Guise, Sir William Vernon, Bart., F.G.S., F.L.S. Elmore-court, near Gloucester.
1862. ‡Gunn, Rev. John, M.A. Irstedd Rectory, Norwich.
1866. §Günther, Albert C. L. G., M.D., F.R.S. British Museum, London, W.C.
1860. *Gurney, Samuel, M.P., F.R.G.S. 20 Hanover-square, London, W.
*Gutch, John James. 88 Micklegate, York.
1859. ‡*Guthrie, Frederick.*
1864. §Guyon, George. South Cliff Cottage, Ventnor, Isle of Wight.
1857. ‡Gwynne, Rev. John. St. Columba's College, Dublin.

Hackett, Michael. Brooklawn, Chapelizod, Dublin.
1865. §Hackney, William. 3 Great George-street, Westminster, London, S.W.
Hackworth, Timothy. Darlington.
1865. §Haden, W. H. Cawney Bank Cottage, Dudley.
1866. *Haddon, Frederick. The Park, Nottingham.
1862. ‡Haddon, Frederick William, Assistant-Secretary to the Statistical Society of London. 12 St. James's-square, London, S.W.
1866. ‡Haddon, Henry. Lenton Field, Nottingham.
Haden, G. N. Trowbridge, Wiltshire.
1842. Hadfield, George. Victoria-park, Manchester.
1848. ‡Hadland, William Jenkins. Banbury, Oxfordshire.
*Hailstone, Edward, F.S.A. Horton Hall, Bradford, Yorkshire.
Halifax, The Right Hon. Viscount. 10 Belgrave-square, London, S.W.; and Hickleston Hall, Doncaster.
1845. ‡Hall, Elias. Castleton, Derbyshire.
1854. *Hall, Hugh Fergus. 17 Dale-street, Liverpool.
1859. ‡Hall, John Frederic. Ellerker House, Richmond, Surrey.
Hall, John R. Sutton, Surrey.
1863. ‡Hall, Thomas Y. Eldon-square, Newcastle-on-Tyne.
*Hall, T. B. Coggeshall, Essex.
1866. *Hall, Townshend M., F.G.S. Pilton, Barnstaple.
1860. §Hall, Walter. 10 Pier-road, Erith.
Halliday, Alexander Henry, M.A., F.L.S., M.R.I.A. Carnmoney, Antrim, Ireland.
1861. ‡Halliday, James. Whalley Court, Whalley Range, Manchester.
1857. ‡Halpin, George, C.E. Rathgar, near Dublin.
Halsall, Edward. 4 Somerset-street, Kingsdown, Bristol.
Halswell, Edmund S., M.A.
1858. *Hambly, Charles Hambly Burbridge, F.G.S. 96 London-road, Leicester.
1866. §Hamilton, Archibald. Southborough, Bromley, Kent.
1857. ‡Hamilton, Charles W. 40 Dominick-street, Dublin.
1865. §Hamilton, Gilbert. Leicester House, Leamington.
Hamilton, The Very Rev. Henry Parr, Dean of Salisbury, M.A., F.R.S. L. & E., F.G.S., F.R.A.S. Salisbury.
1840. *Hamilton, Mathie, M.D. 22 Warwick-street, Glasgow.
1864. ‡Hamilton, Rev. S. R., M.A. Hinton Lodge, Bournemouth.
1851. ‡Hammond, C. C. Lower Brook-street, Ipswich.
1863. ‡Hancock, Albany, F.L.S. 4 St. Mary's-terrace, Newcastle-upon-Tyne.
1852. ‡*Hancock, Charles Brownlow.*
1863. ‡Hancock, John. 4 St. Mary's-terrace, Newcastle-on-Tyne.
1850. ‡Hancock, John. Manor House, Lurgan, Co. Armagh.
1861. ‡Hancock, Walker. 10 Upper Chadwell-street, Pentonville, London.

Year of Election.

1857. ‡Hancock, William J. 74 Lower Gardiner-street, Dublin.
1847. ‡Hancock, W. Nelson, LL.D. 74 Lower Gardiner-street, Dublin.
1865. ‡Hands, M. Coventry.
Handyside, P. D., M.D., F.R.S.E. 11 Hope-street, Edinburgh.
1867. §Hannah, Rev. John, D.C.L. Trinity College, Glenalmond.
1859. ‡Hannay, John. Montcoffer House, Aberdeen.
1853. ‡Hansell, Thomas T. 2 Charlotte-street, Sculcoates, Hull.
*Harcourt, A. Vernon, M.A., F.C.S. Christ Church, Oxford.
Harcourt, Rev. C. G. Vernon, M.A. Rothbury, Northumberland.
Harcourt, Egerton V. Vernon, M.A., F.G.S. Whitwell Hall, Yorkshire.
*Harcourt, Rev. William V. Vernon, M.A., F.R.S., F.G.S., Hon. M.R.I.A. Nuneham Park, Oxford.
1849. ‡Harding, Charles. Tamworth.
1865. ‡Harding, Charles. Harborne Heath, Birmingham.
1864. §Hardwicke, Robert, F.L.S. 192 Piccadilly, London, W.
1858. *Hardy, Charles. Odsall House, Bradford, Yorkshire.
*Hare, Charles John, M.D., Professor of Clinical Medicine in University College, London. 41 Brook-street, Grosvenor-square, London, S.W.
Hare, Samuel. 9 Langham-place, London, W.
Harford, Summers. Reform Club, London, S.W.
1858. ‡Hargrave, James. Burley, near Leeds.
1853. §Harkness, Robert, F.R.S. L. & E., F.G.S., Professor of Geology in Queen's College, Cork.
Harkworth, Timothy. Soho Shilden, Darlington.
1862. *Harley, George, M.D., F.C.S., Professor of Practical Physiology and Histology in University College, London, W.C.
*Harley, John. Ross Hall, near Shrewsbury.
1862. *Harley, Rev. Robert, F.R.S., F.R.A.S., Professor of Mathematics and Logic in Airedale College, Bradford. The Manse, Brighouse, Yorkshire.
1861. ‡Harman, H. W., C.E. 16 Booth-street, Manchester.
*Harris, Alfred. Ryshwall Hall, near Bingley, Yorkshire.
*Harris, Alfred, jun. Bradford, Yorkshire.
1863. ‡Harris, Charles. 6 Somerset-terrace, Newcastle-on-Tyne.
Harris, The Hon. and Rev. Charles, F.G.S. Bremhill, Chippenham, Wiltshire.
1842. **Harris, George William.*
*Harris, Henry. Heaton Hall, near Bradford.
1845. ‡Harris, Henry H. Cambridge.
1863. ‡Harris, T. W. Grange, Middlesborough-on-Tees.
1862. ‡Harris, William Harry, F.C.S. 33 Gold-street, Northampton.
1860. ‡Harrison, Rev. Francis, M.A. Oriel College, Oxford.
1864. §Harrison, George. Barnsley, Yorkshire.
1858. *Harrison, James Park, M.A. Garlands, Ewhurst, Surrey.
1853. ‡Harrison, Robert. 36 George-street, Hull.
1863. ‡Harrison, T. E. Engineers' Office, Central Station, Newcastle-on-Tyne.
1853. *Harrison, William, F.S.A., F.G.S. Galligreaves Hall, near Blackburn, Lancashire.
1849. ‡Harrowby, The Earl of, K.G., D.C.L., F.R.S., F.R.G.S. 39 Grosvenor-square, London, S.W.; and Sandon Hall, Lichfield.
1859. *Hart, Charles. 54 Wych-street, Strand, London, W.C.
1861. *Harter, J. Collier. Chapel Walks, Manchester.
1842. *Harter, William. Hope Hall, Manchester.
1856. ‡Hartland, F. Dixon, F.S.A., F.R.G.S. The Oaklands, near Cheltenham.

Year of Election.

Hartley, James. Sunderland.
Hartley, J. B. Bootle, near Liverpool.
1854. §Hartnup, John, F.R.A.S. Liverpool Observatory, Bidston, Birkenhead.
1850. ‡Harvey, Alexander. 4 South Wellington-place, Glasgow.
*Harvey, Joseph Charles. Cork.
Harvey, J. R., M.D. St. Patrick's-place, Cork.
1862. *Harwood, John, jun. Mayfield, Bolton-le-moors.
1855. ‡Hassall, Arthur Hill. 8 Bennett-street, St. James's, London, S.W.
Hastings, Rev. H. S. Martley Rectory, Worcester.
1842. *Hatton, James. Richmond House, Higher Broughton, Manchester.
1863. ‡Hatton, James W. Old Lodge, Old Trafford, Manchester.
Haughton, James, M.R.D.S. 34 Eccles-street, Dublin.
1857. ‡Haughton, Rev. Samuel, M.D., M.A., F.R.S., M.R.I.A., F.G.S., Professor of Geology in the University of Dublin. Trinity College, Dublin.
1857. ‡Haughton, S. Wilfred. Grand Canal-street, Dublin.
*Haughton, William. 28 City Quay, Dublin.
1856. ‡*Haville, Henry.*
1847. ‡Hawkins, Rev. Edward, D.D., Provost of Oriel College, Oxford.
Hawkins, John Heywood, M.A., F.R.S., F.G.S. Bignor Park, Petworth, Sussex.
Hawkins, John Isaac, C.E.
**Hawkins, Thomas, F.G.S.*
1851. ‡*Hawkins, W. W.*
*Hawkshaw, John, F.R.S., F.G.S. 43 Eaton-place, London, S.W.
1864. *Hawkshaw, John Clarke, M.A., F.G.S. 43 Eaton-place, London, S.W.
1853. ‡Haworth, Benjamin, J.P. Hull Bank House, near Hull.
1863. ‡Hawthorn, William. The Cottage, Benwell, Newcastle-upon-Tyne.
1859. ‡Hay, Sir Andrew Leith, Bart. Rannes, Aberdeenshire.
1861. *Hay, Sir John D. United Service Club, London, S.W.
1858. ‡Hay, Samuel. Albion-place, Leeds.
1867. §Hay, William. 21 Magdalen Yard-road, Dundee.
1857. ‡Hayden, Thomas, M.D. 30 Harcourt-street, Dublin.
1856. ‡Hayward, J. Curtis. Quedgeley, near Gloucester.
1858. *Hayward, Robert Baldwin, M.A. Harrow-on-the-hill.
1851. ‡Head, Jeremiah. Woodbridge-road, Ipswich.
1861. *Heald, James. Parr's Wood, Didsbury, near Manchester.
1863. ‡Heald, Joseph. 22 Leazes-terrace, Newcastle-on-Tyne.
1854. ‡Healey, Elkanah. Gateacre, Liverpool.
1861. *Heape, Benjamin. Northwood, near Manchester.
1865. ‡Hearder, William. Torquay.
1866. ‡Heath, Rev. D. J. Esher, Surrey.
1854. ‡*Heath, Edward.*
1863. ‡Heath, G. Y., M.D. Westgate-street, Newcastle-on-Tyne.
Heath, John. 11 Albemarle-street, London, W.
1861. §Heathfield, W. E., F.C.S., F.R.G.S. 20 King-street, St. James's, London, S.W.
1865. §Heaton, Harry. Warstone, Birmingham.
1858. *Heaton, John Deakin, M.D. Claremont, Leeds.
1865. ‡Heaton, Ralph. Harborne Lodge, near Birmingham.
1863. ‡Heckels, Richard. Pensher, near Fencehouses, Durham.
1855. ‡Hector, James, M.D., F.R.S.E., F.G.S., F.R.G.S., Geological Survey of Otago. New Zealand.
1867. §Heddle, M. Foster, M.D. St. Andrew's, N. B.
1863. ‡Hedley, Thomas. Cox Lodge, near Newcastle-on-Tyne.
*Heelis, Thomas. Princes-street, Manchester.

Year of Election.

1854. ‡Heldenmaier, B., Ph.D. Worksop, Notts.
1862. ‡Helm, George F. 58 Trumpington-street, Cambridge.
1857. *Hemans, George William, C.E., M.R.I.A.. 32 Leinster-gardens, Hyde Park, London, W.
1867. §Henderson, Alexander. Dundee.
1845. ‡Henderson, Andrew. 120 Gloucester-place, Portman-square, London.
1866. §Henderson, James, jun. Dundee.
1856. ‡Hennessy, Henry G., F.R.S., M.R.I.A. Wynnefield, Rathgar, Co. Dublin.
1857. ‡Hennessy, John Pope. Inner Temple, London, E.C.
Henry, Franklin. Portland-street, Manchester.
Henry, J. Snowdon. East Dene, Bonchurch, Isle of Wight.
Henry, Mitchell. Stratheden House, Hyde Park, London, W.
*Henry, William Charles, M.D., F.R.S., F.R.G.S. Haffield, near Ledbury, Herefordshire.
Henwood, William Jory, F.R.S., F.G.S. 3 Clarence-place, Penzance.
1855. *Hepburn, J. Gotch. Clapham Common, Surrey, S.
1855. ‡Hepburn, Robert. 70 Portland-place, London, W.
Hepburn, Thomas. Clapham, London, S.
Hepworth, John Mason. Ackworth, Yorkshire.
1856. ‡Hepworth, Rev. Robert. 2 St. James's-square, Cheltenham.
1864. §Herapath, William Bird, M.D., F.R.S. L. & E. Old Market-street, Bristol.
*Herbert, Thomas. Nottingham.
1852. ‡Herdman, John. 9 Wellington-place, Belfast.
1866. §Herrick, Perry. Bean Manor Park, Loughborough.
Herschel, Sir John Frederick William, Bart., K.H., M.A., D.C.L., F.R.S. L. & E., Hon. M.R.I.A., F.G.S., F.R.A.S. Collingwood, near Hawkhurst, Kent.
1861. ‡Hertz, James. Sedgley-park, Prestwich, near Manchester.
1851. ‡Hervey, The Rev. Lord Arthur. Ickworth, Suffolk.
1865. ‡Heslop, Dr. Birmingham.
1863. ‡Heslop, Joseph. Pilgrim-street, Newcastle-on-Tyne.
1832. ‡Hewitson, William C. Oatlands, Surrey.
Hey, Rev. William, M.A., F.C.P.S. Clifton, York.
1866. *Heymann, Albert. West Bridgford, Nottinghamshire.
1866. §Heymann, L. West Bridgford, Nottinghamshire.
1861. *Heywood, Arthur Henry. Sedgley-park, Manchester.
*Heywood, James, F.R.S., F.G.S., F.S.A., F.R.G.S. 26 Palace-gardens, Kensington, London, W.
1861. *Heywood, Oliver. Acresfield, Manchester.
*Heywood, Robert. The Pike, Bolton.
Heywood, Thomas Percival. Claremont, Manchester.
1854. ‡*Heyworth, Captain L., jun.*
1864. *Hiern, W. P., M.A., F.G.S. St. John's College, Cambridge.
1854. *Higgin, Edward. Liverpool.
1861. *Higgin, James. Hopwood-avenue, Manchester.
Higginbotham, Samuel. Exchange-square, Glasgow.
1866. ‡Higginbottom, John. Nottingham.
1861. ‡Higgins, George. Mount House, Higher Broughton, Manchester.
1854. ‡Higgins, Rev. Henry H., M.A. Rainhill, Liverpool.
1861. *Higgins, James. Stocks House, Cheetham, Manchester.
1854. ‡Highley, Samuel, F.G.S. Boxhill, near Dorking, Surrey.
1842. *Higson, Peter. Irwell-terrace, Lower Broughton, Manchester.
Hildyard, Rev. James, B.D., F.C.P.S. Ingoldsby, near Grantham, Lincolnshire.
1862. *Hiley, Rev. Simeon. St. John's College, Cambridge.
Hill, Arthur. Bruce Castle, Tottenham, London, N.

Year
Election.

*Hill, Rev. Edward, M.A., F.G.S. Sheering Rectory, Harlow.
1857. ‡Hill, John. Tullamore, Ireland.
1855. ‡*Hill, Lanreuce.*
*Hill, Sir Rowland, K.C.B., D.C.L., F.R.S., F.R.A.S. Hampstead, London, N.W.
1864. ‡Hill, William. Combe Hay, Bristol.
1863. §Hills, F. C. Chemical Works, Deptford, Kent, S.E.
1858. ‡Hincks, Rev. Thomas, B.A. Mountside, Leeds.
Hincks, Rev. William, F.L.S., Professor of Natural History in University College. Toronto, Canada West.
Hindley, Rev. H. J. Walton-on-the-hill, Lancashire.
1852. *Hindmarsh, Frederick, F.G.S., F.R.G.S. 4 New Inn, Strand, London, W.C.
*Hindmarsh, Luke. Alnwick.
1865. §Hinds, James, M.D. Queen's College, Birmingham.
1863. ‡Hinds, William, M.D. Parade, Birmingham.
1861. *Hinmers, William. Cleveland House, Birkdale, Southport.
1858. §Hirst, John, jun. Dobcross, near Manchester.
1861. *Hirst, T. Archer, Ph.D., F.R.S., F.R.A.S. (*General Secretary*), Professor of Mathematics in University College, London. The Athenæum Club, London, S.W.
1856. ‡Hitch, Samuel, M.D. Sandywell Park, Gloucestershire.
1860. ‡Hitchman, John. Leamington.
*Hoare, Rev. George Tooker. Tandridge, Godstone.
Hoare, J. Gurney. Hampstead, London, N.W.
1864. ‡Hobhouse, Arthur Fane. 24 Cadogan-place, London, S.W.
1864. ‡Hobhouse, Charles Parry. 24 Cadogan-place, London, S.W.
1864. ‡Hobhouse, Henry William. 24 Cadogan-place, London, S.W.
1863. §Hobson, A. S., F.C.S. 3 Upper Heathfield-terrace, Turnham Green, London, W.
1866. ‡*Hockin, Charles.*
1852. ‡Hodges, John F., M.D., Professor of Agriculture in Queen's College, Belfast. 23 Queen-street, Belfast.
1863. *Hodgkin, Thomas. (*Local Treasurer.*) Newcastle-on-Tyne.
1847. ‡Hodgkinson, Rev. G. C. The Lodge, Louth.
*Hodgson, Adam. Everton, Liverpool.
Hodgson, Joseph, F.R.S. 60 Westbourne-terrace, London, W.
1863. ‡Hodgson, Robert. Whitburn, Sunderland.
1863. ‡Hodgson, R. W. North Dene, Gateshead.
Hodgson, Thomas. Market-street, York.
1860. ‡*Hogan, Rev. A. R., M.A.*
1865. *Hofmann, Augustus William, F.R.S., F.C.S. Chemical Laboratory of the University of Berlin.
Hogan, William, M.A., M.R.I.A. Haddington-terrace, Kingstown, near Dublin.
Hogg, John, M.A., F.R.S., F.L.S., F.R.G.S. 8 Serjeants' Inn, London, E.C.; and Norton, Stockton-on-Tees.
1861. ‡Holcroft, George, C.E. Red Lion-court, St. Ann's-square, Manchester.
1854. *Holcroft, George. 82 Great Ducie-street, Strangeways, Manchester.
*Holditch, Rev. Hamnet, M.A. Caius College, Cambridge.
1856. ‡Holland, Henry, M.P. Dumbleton, Evesham.
1858. §Holland, Loton, F.R.G.S. 6 Queen's-villas, Windsor.
1865. ‡Holliday, William. New Street, Birmingham.
*Hollingsworth, John. London-street, Greenwich, Kent, S.E.
1866. *Holmes, Charles. London-road, Derby.
Holmes, Rev. W. R.

Year of Election.

Hone, Joseph, M.R.D.S. 2 Harcourt-street, Dublin.
1851. ‡*Honywood, Robert.*
1858. ‡Hook, The Very Rev. W. F., D.D., Dean of Chichester. Chichester.
1847. ‡Hooker, Joseph D., M.D., D.C.L., (PRESIDENT ELECT,) F.R.S., V.P.L.S., F.G.S., F.R.G.S. Royal Gardens, Kew.
1865. *Hooper, John P. Fremerton House, Balham, London, S.
1861. §Hooper, William. 7 Pall Mall East, London, S.W.
1856. ‡Hooton, Jonathan. 80 Great Ducie-street, Manchester.
1842. Hope, Thomas Arthur. Liverpool.
Hope, William. Wavertree, Liverpool.
1865. §Hopkins, J. S. Jesmond Grove, Edgbaston, Birmingham.
1858. ‡Hopkinson, Joseph, jun. Britannia Works, Huddersfield.
Hornby, Hugh. Sandown, Liverpool.
1864. *Horner, Rev. J. J. H. Mells Rectory, Frome.
1858. *Horsfall, Abraham. Leeds.
Horsfall, Charles. Everton, Liverpool.
Horsfall, John. Wakefield.
1854. ‡Horsfall, Thomas Berry, M.P. Liverpool.
1855. *Horsfield, George. Brampton-grove, Smedley-lane, Cheetham, Manchester.
1856. ‡Horsley, John H. 389 High-street, Cheltenham.
Hotham, Rev. Charles, M.A., F.L.S. Roos Patrington, Yorkshire.
1859. §Hough, Joseph. Wrottesley, near Wolverhampton.
Houghton, The Right Hon. Lord, D.C.L., F.R.G.S. 16 Upper Brook-street, London, W.
Houghton, James. Rodney-street, Liverpool.
1842. *Houldsworth, Henry. Newton-street, Manchester.
1858. ‡Hounsfield, James. Hemsworth, Pontefract.
1842. *Houtson, John.*
Hovenden, W. F., M.A. Bath.
1859. ‡Howard, Captain John Henry, R.N. The Deanery, Lichfield.
1863. ‡Howard, Philip Henry. Corby Castle, Carlisle.
1857. ‡Howell, Henry H. Museum of Practical Geology, Jermyn-street, London, S.W.
1865. *Howlett, Rev. Frederick, F.R.S. St. Augustine's, Hurst-green, Sussex.
1863. §Howorth, H. H. Castleton Hall, Rochdale.
1863. ‡Howse, R. South Shields.
1854. ‡Howson, Rev. J. S., Dean of Chester. Chester.
1835. *Hudson, Henry, M.D., M.R.I.A. Glenville, Fermoy, Co. Cork.
Hudson, John. Oxford.
1842. §Hudson, Robert, F.R.S., F.G.S., F.L.S. Clapham Common, London, S.
1867. §Hudson, William H. H., M.A. St. John's College, Cambridge.
1858. ‡Huggins, William, F.R.A.S. Upper Tulse-hill, London, S.
1857. §Huggon, William. 30 Park-row, Leeds.
Hughes, D. Abraham. 9 Grays Inn-square, London, W.C.
Hughes, Frederick Robert.
1863. ‡Hughes, T. W. 4 Hawthorn-terrace, Newcastle-on-Tyne.
1865. ‡Hughes, W. R., F.L.S. General Hospital, Birmingham.
Hull, Arthur H. Brighton.
1867. §Hull, Edward, F.R.S., F.G.S. Geological Museum, Jermyn-street, London, S.W.
**Hull, William Darley, F.G.S.*
*Hulse, Sir Edward, D.C.L. 4 New Burlington-street, London, W.; and Breamore House, Salisbury.
1861. ‡Hume, Rev. A., D.C.L., F.S.A. Everton, Liverpool.
1845. ‡Humpage, Edward. Bristol.
1856. ‡*Humphreys, E. R., LL.D.*

Year of Election.

1856. ‡Humphries, David James. 1 Keynsham-parade, Cheltenham.
1862. *Humphry, George Murray, M.D., F.R.S., Professor of Anatomy in the University of Cambridge. Trumpington-street, Cambridge.
1863. *Hunt, Augustus H., Ph.D. Pelaw Main Office, Newcastle-on-Tyne.
1860. ‡Hunt, James, Ph.D., F.S.A. Ore House, near Hastings.
1865. §Hunt, J. P. Gospel Oak Works, Tipton.
1840. §Hunt, Robert, F.R.S., Keeper of the Mining Records. Museum of Practical Geology, Jermyn-street, London, S.W.
1864. ‡Hunt, W. 72 Pulteney-street, Bath.
Hunter, Adam, M.D., F.R.S.E. Edinburgh.
Hunter, Andrew G. Low Walker, Newcastle-on-Tyne.
1867. §Hunter, David. Blackness, Dundee.
Hunter, Robert, F.R.S., F.G.S., F.R.A.S., F.S.A. Southwood-lane, Highgate, London, N.
1859. ‡*Hunter, Dr. Thomas, Deputy Inspector-General of Army Hospitals.*
1855. *Hunter, Thomas C. Greenock.
1863. ‡Huntsman, Benjaman. West Retford Hall, Retford.
1861. *Hurst, William John. 2A Victoria-street, Manchester.
1851. ‡*Hurwood, George.*
Husband, William Dalla. Coney-street, York.
*Hutchinson, John. Widnes Dock, Warrington.
1863. ‡Hutt, The Right Hon. Sir W., K.C.B., M.P. Gibside, Gateshead.
Hutton, Crompton. Putney-park, Surrey, S.W.
Hutton, Daniel. 4 Lower Dominick-street, Dublin.
1864. *Hutton, Darnton. 11 Warnford-court, Throgmorton-street, London, E.C.
Hutton, Henry. Eccles-street, Dublin.
1857. ‡Hutton, Henry D. 1 Nelson-street, Dublin.
*Hutton, Robert, M.R.I.A., F.G.S. Putney Park, Surrey.
1861. ‡Hutton, T. Maxwell. Summerhill, Dublin.
1852. ‡Huxley, Thomas Henry, Ph.D., LL.D., F.R.S., F.L.S., F.G.S., Professor of Natural History in the Government School of Mines, and Hunterian Professor of Comparative Anatomy in the Royal College of Surgeons. 26 Abbey Place, St. John's Wood, London.
1846. ‡Huxtable, Rev. Anthony. Sutton Waldron, near Blandford.
Hyde, Edward. Dukinfield, near Manchester.
Hyett, William Henry, F.R.S. Painswick, near Stroud, Gloucestershire.
1847. ‡Hyndman, George C. 5 Howard-street, Belfast.

*Ibbetson, Captain L. L. Boscawen, Chevalier Red Eagle of Prussia *with Swords*, Chevalier de Hohenzollern, F.R.S., F.G.S.
1854. ‡*Ihne, William, Ph.D.*
1861. ‡Iles, Rev. J. H. Rectory, Wolverhampton.
1858. ‡Ingham, Henry. Wortley, near Leeds.
1858. ‡Ingram, Hugo C. Meynell. Temple Newsam, near Leeds.
1858. *Ingram, Hugo Francis Meynell. Temple Newsam, Leeds.
1852. ‡Ingram, J. K., LL.D., M.R.I.A., Regius Professor of Greek. Trinity College, Dublin.
1854. *Inman, Thomas, M.D. Rodney-street, Liverpool.
1856. ‡*Invararity, J. D. Bombay.*
Ireland, R. S., M.D. 121 Stephen's Green, Dublin.
1857. ‡Irvine, Hans, M.A., M.B. 1 Rutland-square, Dublin.
Irwin, Rev. Alexander, M.A. Armagh, Ireland.
1845. ‡Irwin, Thomas. Somerset House, London, W.C.
1862. ‡Iselin, J. F., M.A. Wimbledon, Surrey.
1863. *Ivory, Thomas. 9 Ainslie-place, Edinburgh.

Year of Election.

1865. ‡Jabet, George. Wellington-road, Handsworth, Birmingham.
1859. §Jack, John, M.A. Belhelvie by Whitecairns, Aberdeenshire.
1863. *Jackson, Mrs. H. 24 Hereford-square, Gloucester-road, Old Brompton, London, S.W.
1865. ‡*Jackson, Edwin.*
1858. ‡*Jackson, Edwin W.*
1866. §Jackson, H. W. Springfield, Tooting, Surrey.
Jackson, Professor Thomas, LL.D. St. Andrew's, Scotland.
1855. ‡*Jackson, Rev. William, M.A.*
Jacob, Arthur, M.D. 23 Ely-place, Dublin.
1852. ‡Jacobs, Bethel. 40 George-street, Hull.
1867. *Jaffe, David Joseph. Belfast.
1865. *Jaffray, John. 'Journal' Office, New-street, Birmingham.
1859. ‡James, Edward. 9 Gascoyne-terrace, Plymouth.
1860. ‡James, Edward H. 9 Gascoyne-terrace, Plymouth.
James, Colonel Sir Henry, R.E., F.R.S., F.G.S., M.R.I.A. Ordnance Survey Office, Southampton.
James, Sir John K., Bart., M.R.I.A. 9 Cavendish-row, Dublin.
1863. *James, Sir Walter. 6 Whitehall-gardens, London, S.W.
1858. ‡James, William C. 9 Gascoyne-terrace, Plymouth.
1863. ‡Jameson, John Henry. 10 Catherine-terrace, Gateshead.
1859. *Jamieson, Thomas F., F.G.S. Ellon, Aberdeenshire.
1850. ‡Jardine, Alexander. Jardine Hall, Lockerby.
Jardine, James, C.E., F.R.A.S. Edinburgh.
*Jardine, Sir William, Bart., F.R.S.E. Jardine Hall, Applegarth by Lockerby, Dumfriesshire.
1853. *Jarratt, Rev. John, M.A. North Cave, near Brough, Yorkshire.
Jarrett, Rev. Thomas, M.A., Professor of Arabic in the University of Cambridge. Trunch, Norfolk.
1862. ‡Jeakes, Rev. James, M.A. Harrow.
Jebb, Rev. John. Peterstow Rectory, Ross, Herefordshire.
1842. *Jee, Alfred S. 2 Oxford-square, Hyde Park, London, W.
1856. ‡Jeffery, Henry, M.A. 438 High-street, Cheltenham.
1855. *Jeffray, John. 193 St. Vincent-street, Glasgow.
1867. §Jeffreys, Howell. Balliol College, Oxford.
1861. *Jeffreys, J. Gwyn, F.R.S., F.L.S., F.G.S., F.R.G.S. 25 Devonshire-place, Portland-place, London, W.
1854. ‡Jeffreys, W. P. Washington-street, Liverpool.
1852. ‡Jellett, Rev. John H., M.A., M.R.I.A. Professor of Natural Philosophy in Trinity College, Dublin.
1842. Jellicorse, John. Chaseley, near Rugeley, Staffordshire.
1864. ‡Jelly, Dr. W. Paston Hall, near Peterborough.
1862. §Jenkin, Fleeming, F.R.S., Professor of Civil Engineering in University College, London. 6 Duke-street, Adelphi, London, W.C.
1864. §Jenkins, Captain Griffith, C.B., F.R.G.S. Derwin, Welshpool.
*Jenkyns, Rev. Henry, D.D. Durham.
Jennette, Matthew. Birkenhead.
1852. ‡Jennings, Francis M., F.G.S., M.R.I.A. Brown-street, Cork.
1861. ‡Jennings, Thomas. Cork.
*Jenyns, Rev. Leonard, M.A., F.L.S., F.G.S. 1 Darlington-place, Bathwick, Bath.
1845. ‡*Jerdan, William.*
*Jerram, Rev. S. John, M.A. Chobham Vicarage, Bagshot, Surrey.
*Jerrard, George Birch, B.A. Long Stratton, Norfolk.
1845. ‡Jessop, William, sen. Butterley Hall, Derbyshire.
Jessop, William, jun. Butterley Hall, Derbyshire.
1849. ‡Jeune, The Right Rev. Francis, D.C.L., Bishop of Peterborough.
Job, Samuel. Holmfield House, Aigburth, Liverpool.

Year of Election.

1865. *Johnson, G. J. 34 Waterloo-street, Birmingham.
1866. §Johnson, John. Low Pavement, Nottingham.
1866. §Johnson, John G. Basinghall-street, London, E.C.
1861. ‡Johnson, Richard. 27 Dale-street, Manchester.
1863. ‡Johnson, R. S. Hanwell, Fence Houses, Durham.
*Johnson, Thomas. The Hermitage, Frodsham, Cheshire.
1864. ‡Johnson, Thomas. 30 Belgrave-street, Commercial-road, London, E.
Johnson, William. The Wynds Point, Colwall, Malvern, Worcestershire.
1861. ‡Johnson, William Beckett. Woodlands Bank, near Altrincham.
1849. ‡Johnston, Alexander Keith, LL.D., F.R.S.E., F.G.S., F.R.G.S. 4 St. Andrew-square, Edinburgh.
Johnston, Alexander Robert, F.R.S. The Grove, Yoxford, Suffolk.
1859. ‡*Johnston, David, M.D.*
1864. ‡Johnston, David. 13 Marlborough-buildings, Bath.
Johnston, Edward. Field House, Chester.
1845. ‡*Johnston, G., M.D.*
1859. ‡Johnston, James. Newmill, Elgin, N. B.
1864. ‡Johnston, James. Manor House, Northend, Hampstead, London, N.
*Johnstone, James. Alva, near Alloa, Stirlingshire.
*Johnstone, Sir John Vanden Bempde, Bart., M.P., M.A., F.G.S 27 Grosvenor-square, London; and Harkness.
1864. ‡Johnstone, John. 1 Barnard-villas, Bath.
Jollie, Walter. Edinburgh.
1864. ‡Jolly, Thomas. Park View-villas, Bath.
1849. ‡Jones, Baynham. Selkirk Villa, Cheltenham.
*Jones, Christopher Hird. 2 Castle-street, Liverpool.
1856. ‡Jones, C. W. 7 Grosvenor-place, Cheltenham.
Jones, Rev. Harry Longueville, Inspector of Schools.
1858. ‡Jones, Henry Bence, M.A., M.D., F.R.S., Hon. Sec. to the Royal Institution. 84 Brook-street, Grosvenor-square, London, S.W.
1854. ‡Jones, Rev. Henry H. Cemetery, Manchester.
1854. ‡Jones, John. 28 Chapel-street, Liverpool.
1864. ‡Jones, John, F.G.S. Newport-road, Middlesborough.
1865. §Jones, John. 49 Union-passage, Birmingham.
*Jones, Josiah. 2 Castle-street, Liverpool.
*Jones, Robert. 2 Castle-street, Liverpool.
1854. *Jones, R. L. Princes Park, Liverpool.
1847. ‡Jones, Thomas Rymer, Professor of Comparative Anatomy in King's College. 50 Cornwall-road, Westbourne-park, London, W.
1860. ‡Jones, T. Rupert, F.G.S., Professor of Geology and Mineralogy, Royal Military College, Sandhurst. 15 College-terrace, York Town, Surrey.
1864. §Jones, Sir Willoughby, Bart, F.R.G.S. Cranmer Hall, Fakenham, Norfolk.
1853. ‡*Jopling, R. Thompson.*
1851. ‡Josselyn, G. Tower-street, Ipswich.
*Joule, Benjamin St. John B. Thorncliffe, Old Trafford, Manchester.
1842. *Joule, James Prescott, LL.D., F.R.S., F.C.S. Thorncliffe, Old Trafford, Manchester.
1848. *Joy, Rev. Charles Ashfield. Grove Parsonage, near Wantage, Berkshire.
Joy, Henry Holmes, M.A., M.R.I.A. 17 Mountjoy-square East, Dublin.
Joy, William B., M.D. 48 Leeson-street, Dublin.
1847. ‡Jowett, Rev. B., M.A. Balliol College, Oxford.
1858. ‡Jowett, John, jun. Leeds.
*Jubb, Abraham. Halifax.

Year of Election.

1863. ‡Jukes, Rev. Andrew. Spring Bank, Hull.
Jukes, Joseph Beete, M.A., F.R.S., F.G.S., M.R.I.A., Local Director of the Government Geological Survey of Ireland. 51 Stephen's Green, Dublin.

Kane, Sir Robert, M.D., F.R.S., M.R.I.A., Principal of the Royal College of Cork. 51 Stephen's Green, Dublin.
1857. ‡Kavanagh, James W. Grenville, Rathgar, Ireland.
1859. ‡Kay, David, F.R.G.S. 6 North-bridge, Edinburgh.
Kay, John Cunliff. Fairfield Hall, near Skipton.
*Kay, John Robinson. Boss Lane House, Bury, Lancashire.
Kay, Robert. Haugh Bank, Bolton-le-Moors.
1847. *Kay, Rev. William, D.D. Lincoln College, Oxford.
1856. ‡Kay-Shuttleworth, Sir James, Bart. Gawthorpe, Burnley.
1855. ‡Kaye, Robert. Mill Brae, Moodies Burn, by Glasgow.
1855. ‡Keddie, William. 15 North-street, Mungo-street, Glasgow.
1866. §Keene, Alfred. Eastnoor House, Leamington.
1850. ‡Kelland, Rev. Philip, M.A., F.R.S.L. & E., Professor of Mathematics in the University of Edinburgh. 20 Clarendon Crescent, Edinburgh.
1849. ‡Kelly, John, C.E. 38 Mount Pleasant-square, Dublin.
1857. ‡Kelly, John J. 38 Mount Pleasant-square, Dublin.
1864. *Kelly, W. M., M.D. 11 The Crescent, Taunton, Somerset.
1842. *Kelsall, Henry. Rochdale, Lancashire.
1842. Kelsall, J. Rochdale, Lancashire.
1864. *Kemble, Rev. Charles, M.A. Vellore, Bath.
1853. ‡Kemp, Rev. Henry William, B.A. Thanet House, Hull.
1858. ‡Kemplay, Christopher. Leeds.
1850. ‡*Kempson, Samuel.*
1854. ‡Kennedy, James. 33 Erskine-street, Liverpool.
1857. ‡Kennedy, Lieut-Colonel John Pitt. 20 Torrington-square, Bloomsbury, London, W.C.
1858. ‡*Kennie, C. G. Colleton.*
Kenny, Matthias, M.D. 8 Clifton-terrace, Monkstown, Co. Dublin.
Kenrick, Rev. George.
1865. ‡Kenrick, William. Norfolk-road, Edgbaston, Birmingham.
Kent, J. C. Levant Lodge, Earl's Croome, Worcester.
1857. ‡Kent, William T., M.R.D.S. 51 Rutland-square, Dublin.
1857. ‡Kenworth, James Ryley. 7 Pembroke-place, Liverpool.
1857. *Ker, André Allen Murray. Newbliss House, Newbliss, Ireland.
1855. *Ker, Robert. Auchinraith, Glasgow.
1865. *Kerr, William D., M.D., R.N. Bonnyrigg, Edinburgh.
1861. *Keymer, John. Parker-street, Manchester.
1854. ‡Kilpin, Thomas Johnstone. 1 Arrad-street, Liverpool.
1865. *Kinahan, Edward Hudson. 11 Merrion-square North, Dublin.
1860. ‡Kinahan, G. Henry. Geological Survey of Ireland, 51 Stephen's Green, Dublin.
1858. ‡Kincaid, Henry Ellis, M.A. 8 Lyddon-terrace, Leeds.
1854. ‡King, Alfred. 1 Netherfield-road South, Liverpool.
1855. ‡King, Alfred, jun. Everton, Liverpool.
King, The Hon. James, M.R.I.A. Mitchelstown Castle, Co. Cork.
1855. ‡King, James. Levernholme, Hurlet, Glasgow.
1851. ‡*King, John.*
1851. ‡King, John. Rose-hill, Ipswich.
King, Joseph. Anfield-road, Liverpool.
1864. §King, Kelburne, M.D. 27 George Street; and Royal Institution, Hull.
1860. *King, Mervyn Kersteman. Avonside, Clifton, Bristol.
1842. King, Richard, M.D. Savile-row, London, W.

Year of Election.

King, Rev. Samuel, M.A., F.R.A.S. St. Aubins, Jersey.
1862. ‡King, Rev. Samuel William, F.G.S., F.S.A. Saxlingham Rectory, near Norwich.
King, William Poole, F.G.S. Avonside, Clifton, Bristol.
1862. ‡Kingsley, Rev. Charles, M.A., Professor of Modern History in the University of Cambridge. Eversley Rectory, Winchfield.
1861. ‡Kingsley, John. 30 St. Ann's-street, Manchester.
1845. ‡Kingsley, Rev. W. T. South Kelvington, Thirsk.
1835. Kingstone, A. John, M.A. Mosstown, Longford, Ireland.
1867. §Kinloch, Colonel. Kilray, Logie, N. B.
1867. *Kinnaird, The Hon. Arthur Fitzgerald, M.P. Rossie Priory, Inchture, Perthshire.
1863. ‡Kinnaird, The Right Hon. Lord., K.T., F.G.S. Rossie Priory, Inchture, Perthshire.
Kinnear, J. G., F.R.S.E. Glasgow.
1863. ‡Kirkaldy, David. 28 Bartholomew-road North, London, N.W.
1867. §Kirkland, William. Oak Lodge, Dundee.
1860. ‡Kirkman, Rev. Thomas P., M.A., F.R.S. Croft Rectory, near Warrington.
Kirkpatrick, Rev. W. B., D.D. 48 North Great George-street, Dublin.
1850. ‡Kirkwood, Anderson. 151 West George-street, Glasgow.
1849. ‡Kirshaw, John William, F.G.S. Warwick.
1858. ‡Kitson, James. Leeds.
Knight, Sir A. J., M.D.
Knipe, A. J. Moorville, Carlisle.
Knowles, George Beauchamp, Professor of Botany in Queen's College, Birmingham. St. Paul's-square, Birmingham.
1842. Knowles, John. Old Trafford Bank House, Old Trafford, Manchester.
*Knowles, William. 2 Clarence-place, Newport, Monmouthshire.
*Knox, G. James. 2 Finchley New-road, St. John's-wood, London.
Knox, Henry.
Knox, Rev. H. B., M.A., M.R.I.A. Deanery, Hadleigh, Suffolk.
Kutz, Andrew.
1861. *Kyllmann, Max. 28 Brazennose-street, Manchester.
1865. ‡Kynnersley, J. C. S. The Leveretts, Handsworth, Birmingham.

Lace, Ambrose. Liverpool.
1858. §Lace, Francis John. Stone Gapp, Cross-hill, Leeds.
1862. §Lackenstein, Dr. (Care of Messrs. Smith and Elder, Cornhill, London.)
1842. Lacy, Henry C. Withdeane Hall, near Brighton.
1859. §Ladd, William. 11 & 13 Beak-street, Regent-street, London, W.
1850. ‡Laing, David, F.S.A. Scotl. Signet Library, Edinburgh.
Laird, John, M.P. Birkenhead.
1859. §Lalor, John Joseph, M.R.I.A. 2 Longford-terrace, Monkstown, Co. Dublin.
Lamb, David.
Lambert, Richard. Newcastle-on-Tyne.
1846. *Laming, Richard. 36 Hamilton-road, Prestonville, Brighton.
1854. ‡Lamport, William James. Liverpool.
1859. ‡Lang, Rev. John Marshall. Fyvie, Aberdeen.
1864. §Lang, R. Greatwick Hall, Barrow Gurney, near Bristol.
*Langton, William. Manchester.
1840. ‡Lankester, Edwin, M.D., LL.D., F.R.S., F.L.S. 23 Great Marlborough-street, London, W.
1865. §Lankester, E. Ray. Christ Church, Oxford.
*Larcom, Major-General Sir Thomas Aiskew, K.C.B., R.E., F.R.S., M.R.I.A. Phœnix Park, Dublin.

Year of Election.

Lassell, William, F.R.S., F.R.A.S. Ray Lodge, Maidenhead.

1860. ‡Lassell, William, jun. The Brook, near Liverpool.

1861. *Latham, A. G. Cross-street, Manchester.

1845. ‡Latham, Robert G., M.A., M.D., F.R.S. 9 Disraeli-road, Putney, S.W.

*La Touche, David Charles, M.R.I.A. Castle-street, Dublin.

1857. ‡Law, Hugh. 4 Great Denmark-street, Dublin.

1862. ‡Law, Rev. James Edmund, M.A. Little Shelford, Cambridgeshire.

Law, Rev. William, M.A.

Lawley, The Hon. Francis Charles. Escrick Park, near York.

Lawley, The Hon. Stephen Willoughby. Escrick Park, near York.

1857. ‡Lawson, James A., LL.D., M.R.I.A. 27 Fitzwilliam-street, Dublin.

1855. ‡Lawson, John. Mountain Blue Works, Camlachie.

1858. ‡Lawson, Samuel. Kirkstall, near Leeds.

1863. ‡Lawton, Benjamin C. Neville Chambers, 44 Westgate-street, Newcastle-upon-Tyne.

1853. ‡Lawton, William. Manor House-street, Hull.

Laycock, Thomas, M.D., Professor of the Practice of Medicine in the University of Edinburgh. 4 Rutland-street, Edinburgh.

1865. ‡Lea, Henry. 35 Paradise-street, Birmingham.

1857. ‡Leach, Capt. R. E. Mountjoy, Phœnix Park, Dublin.

Leadbetter, John. Glasgow.

1847. *Leatham, Edward Aldam. Whitley Hall, Huddersfield.

1858. ‡Leather, George. Knostrop, near Leeds.

*Leather, John Towlerton. Leventhorpe Hall, near Leeds.

1858. ‡Leather, John W. Newton Green, Leeds.

1863. ‡Leavers, J. W. The Park, Nottingham.

1858. *Le Cappelain, John. Wood-lane, Highgate, London, N.

1858. ‡Ledgard, William. Potter Newton, near Leeds.

1842. Lee, Daniel. Springfield House, Pendlebury, Manchester.

1861. ‡Lee, Henry. Irwell House, Lower Broughton, Manchester.

Lee, Henry, M.D. Weatheroak, Alve Church, near Bromsgrove.

1853. *Lee, John Edward, F.G.S., F.S.A. The Priory, Caerleon, Monmouthshire.

1845. ‡Lees, Dr. Frederick R. Burmantofts Hall, Leeds.

1850. ‡Lees, George, LL.D. Rillbank, Edinburgh.

1854. ‡Lees, Samuel. Portland-place, Ashton-under-Lyne.

1859. ‡Lees, William. 5 Meadow Bank, Edinburgh.

*Leese, Joseph, jun. Glenfield, Altrincham.

*Leeson, Henry B., M.A., M.D., F.R.S. The Maples, Bonchurch, Isle of Wight.

*Lefroy, John Henry, Brigadier-General R.A., F.R.S., F.R.G.S., President of the Ordnance Select Committee. Grosvenor House, Blackheath, Kent, S.E.

1845. ‡*Legard, Capt. William. India.*

*Legh, Major George Cornwall, M.P. High Legh, Cheshire.

1856. ‡Leigh, The Right Hon. Lord, D.C.L. 37 Portman-square, London, W.; and Stoneleigh Abbey, Kenilworth.

1861. *Leigh, Henry. The Poplars, Patricroft, near Manchester.

Leigh, John Shaw. Childerall Hall, near Liverpool.

*Leinster, Augustus Frederick, Duke of, M.R.I.A. 6 Carlton House-

1867. §Leishman, James. Gateacre, Liverpool.

terrace, London, S.W.

1859. ‡Leith, Alexander. Glenkindie, Inverkindie, N.B.

1860. ‡Lempriere, Charles, D.C.L. St. John's College, Oxford.

1863. *Lendy, Capt. Auguste Frederic. Practical Military College, Sunbury, Middlesex, S.W.

1867. §Leng, John. "Advertiser" Office, Dundee.

Year of Election.

1861. ‡Lennox, A. C. W. 7 Beaufort-gardens, Brompton, London, S.W.
Lentaigne, John, M.D. Tallaght House, Co. Dublin; and 14 Great Dominick-street, Dublin.
Lentaigne, Joseph. 12 Great Denmark-street, Dublin.
1861. ‡Leppoc, Henry Julius. Kersal Crag, near Manchester.
1856. ‡Leslie, Colonel J. Forbes. Bothiekorman, Aberdeenshire.
1852. ‡Leslie, T. E. Cliffe, LL.B., Professor of Jurisprudence and Political Economy, Queen's College, Belfast.
1859. ‡Leslie, William. Warthill, Aberdeenshire.
1846. ‡Letheby, Henry, M.B., F.L.S., Medical Officer to the City of London. 41 Finsbury-square, London, E.C.
1866. §Levi, Leone, F.S.A., F.S.S., Professor of Commercial Law in King's College, London. 10 Farrar's-building, Temple, London, E.C.
1847. ‡Ley, Rev. Jacob, M.A. Staverton, near Daventry.
1853. ‡Liddell, George William Moore. Sutton House, near Hull.
1860. ‡Liddell, The Very Rev. H. G., D.D., Dean of Christ Church, Oxford.
1855. ‡Liddell, John. 8 Clelland-street, Glasgow.
1859. ‡Ligertwood, George. Blair by Summerhill, Aberdeen.
1864. §Lightbody, Robert, F.G.S. Ludlow, Salop.
1862. ‡Lilford, The Right Hon. Lord, F.L.S. Lilford Hall, Oundle, Northamptonshire.
*Limerick, Charles Graves, D.D., M.R.I.A., Lord Bishop of. Limerick.
*Lindsay, Charles. Hedge-park, Lanark.
*Lindsay, Henry L., C.E., M.R.I.A. 1 Little Collins-street West, Montreal, Canada.
1855. *Lindsay, John H. 317 Bath-street, Glasgow.
1842. *Lingard, John R., F.G.S. Mayfield, Shortlands, by Bromley, Kent.
Lingwood, Robert M., M.A., F.L.S., F.G.S.
Lister, James. Liverpool Union Bank, Liverpool; and Greenbank, Everton.
1858. *Lister, John, F.G.S. Shibden Hall, near Halifax.
*Lister, Joseph Jackson, F.R.S. Upton, Essex.
Littledale, Harold. Liscard Hall, Cheshire.
1854. ‡Littledale, Thomas. Highfield House, Liverpool.
1861. *Liveing, G. D., M.A., F.C.S., Professor of Chemistry in the University of Cambridge. 12 Hill's-road, Cambridge.
1864. §Livesay, J. G. Meaford Cottage, Ventnor, Isle of Wight.
1860. ‡Livingstone, Rev. Thomas Gott, Minor Canon of Carlisle Cathedral.
Lloyd, Rev. A. R. Hengold, near Oswestry.
Lloyd, Rev. C., M.A. Whittington, Oswestry.
1848. ‡Lloyd, Rev. David. Carmarthen.
1842. Lloyd, Edward. King-street, Manchester.
1854. ‡*Lloyd, F. Geisler.*
1847. **Lloyd, George Whitelocke.*
1865. ‡Lloyd, G. B. Wellington-road, Ebgbaston, Birmingham.
*Lloyd, George, M.D., F.G.S. Birmingham.
*Lloyd, Rev. Humphrey, D.D., LL.D., F.R.S. L. & E., M.R.I.A., Provost of Trinity College, Dublin.
1865. ‡Lloyd, John. Queen's College, Birmingham.
Lloyd, Rev. Rees Lewis. Belper, Derbyshire.
1849. ‡Lloyd, William, M.D. Army and Navy Club, London.
1865. *Lloyd, Wilson. Moor Hall, Sutton Coldfield, near Birmingham.
1854. *Lobley, James Logan, F.G.S. 50 Landsdowne-road, Kensington Park, London, W.
1853. *Locke, John. Royal Dublin Society, Kildare-street, Dublin.
1867. *Locke, John. 83 Addison-road, Kensington, London, W.
*Lockey, Rev. Francis. Swainswick, near Bath.
Lockhart, Alexander M'Donald.

Year of Election.

1863. §Lockyer, J. Norman, F.R.A.S. Victoria-road, Finchley-road, London.
1858. ‡Loft, John. 17 Albion-street, Hull.
Loftus, William Kennett, F.G.S. Calcutta.
*Logan, Sir William Edmond, LL.D., F.R.S., F.G.S., F.R.G.S., Director of the Geological Survey of Canada. Montreal, Canada.
1862. ‡Long, Andrew, M.A. King's College, Cambridge.
1851. ‡Long, P. B. Museum-street, Ipswich.
1851. ‡Long, William, F.G.S. Hurts Hall, Saxmundham, Suffolk.
1866. §Longdon, F. Derby.
1857. ‡Longfield, Rev. George. 25 Trinity College, Dublin.
Longfield, Mountifort, LL.D., M.R.I.A., Regius Professor of Feudal and English Law in the University of Dublin. 47 Fitzwilliam-square, Dublin.
1861. *Longman, William, F.G.S. 36 Hyde Park-square, London, W.
1859. ‡Longmuir, Rev. John, M.A., LL.D. 14 Silver-street, Aberdeen.
Longridge, W. S. Oakhurst, Ambergate, Derbyshire.
1865. §Longsdon, Robert. Church House, Bromley, Kent.
1861. *Lord, Edward. York-street, Todmorden.
1855. ‡Lorimer, Rev. J. G., D.D. 6 Woodside-place, Glasgow.
1863. ‡Losh, W. S. Wreay Syke, Carlisle.
1867. §Low, J. T. Monifieth, by Dundee.
1863. *Lowe, Arthur S. H. Gosfield Hall, near Nottingham.
1861. *Lowe, Edward Joseph, F.R.S., F.R.A.S., F.L.S., F.G.S., F.M.S. Highfield House Observatory, near Nottingham.
Lowe, George, F.R.S., F.G.S., F.R.A.S. 9 St. John's-wood Park, London, N.W.
1850. ‡Lowe, William Henry, M.D., F.R.S.E. Balgreen, Slateford, Edinburgh.
Lowndes, Matthew D. 49 Edge-lane, near Liverpool.
1853. *Lubbock, Sir John, Bart., F.R.S., F.L.S., F.G.S. High Elms, Farnborough, Kent.
1849. *Luckcock, Howard. Oak-hill, Edgbaston, Birmingham.
1849. ‡Lucy, William. Edgbaston, Birmingham.
1867. *Luis, John Henry. Hawkhill House, Dundee.
1866. *Lund, Charles. Market-street, Bradford.
1850. *Lundie, Cornelius. Rhymney Railway, Cardiff.
1853. ‡Lunn, William Joseph, M.D. 23 Charlotte-street, Hull.
1858. *Lupton, Arthur. Headingley, near Leeds.
1864. *Lupton, D., Jun. Leeds.
1866. §Lycett, Francis. 18 Highbury-grove, London, N.
*Lyell, Sir Charles, Bart., M.A., LL.D., D.C.L., F.R.S., F.L.S., V.P.G.S., Hon. M.R.S.Ed. 73 Harley-street, Cavendish-square, London, W.
1864. ‡Lyne, Francis. (Care of Sydney Smith, Esq., Charlotte-row, Mansion House, London, E.C.)
1857. ‡Lyons, Robert D. 31 Upper Merrion-street, Dublin.
1862. *Lyte, Maxwell F., F.C.S. Bagnères de Bigorre, France.
1849. ‡Lyttelton, The Right Hon. Lord, D.C.L. 17 St. James's-place, London, S.W.

1859. ‡Mabson, John. Heyning, Westmoreland.
1852. ‡MacAdam, James, jun. Beavor Hall, Belfast.
1852. ‡MacAdam, Robert. 18 College-square East, Belfast.
1854. *Macadam, Stevenson, Ph.D., F.R.S.E., F.C.S., Lecturer on Chemistry. Surgeons' Hall, Edinburgh.
1852. ‡*Macaldin, J. J., M.D.*
*M'Andrew, Robert, F.R.S. Isleworth House, Isleworth, Middlesex.
1866. *M'Arthur, A. Raleigh Hall, Brixton Rise, London, S.

Year of Election.

1855. ‡*M'Arthur, Richard, W. J.*
1840. Macaulay, Dr. James. 22 Cambridge-road, Kilburne, London, N.W.
1857. ‡*Macauley, James William.*
*MacBrayne, Robert. Messrs. Black and Wingate, 9 Exchange-square, Glasgow.
1866. ‡M'Callan, Rev. J. F., M.A. St. Matthew's Parsonage, Nottingham.
1855. ‡M'Callum, Archibald K., M.A. House of Refuge, Duke-street, Glasgow.
1863. †M'Calmont, Robert. Gatton Park, Reigate.
1855. ‡M'Cann, James, F.G.S. Holmfrith, Yorkshire.
1857. ‡M'Causland, Dominick. 12 Fitzgibbon-street, Dublin.
1865. *M'Clean, John Robinson. 23 Great George-street, Westminster, London, S.W.
M'Clelland, James. 73 Kensington Gardens-square, Bayswater.
1855. ‡M'Clelland, James. 10 Claremont-terrace, Glasgow.
1856. ‡*M'Clelland, John. Calcutta.*
*M'Connel, James. Bent-hill, Prestwich, near Manchester.
1859. **M'Connell, David C., F.G.S.*
1858. ‡M'Connell, J. E. Woodlands, Great Missenden.
1852. ‡M'Cosh, Rev. James, M.A., Professor of Logic, &c., Queen's College, Belfast.
1851. ‡M'Coy, Professor Frederick, F.G.S., Professor of Zoology and Natural History in the University of Melbourne, Australia.
M'Cullagh, John, A. B.
*M'Culloch, George, M.D. Cincinnati, United States.
1852. ‡M'Dermott, Edward. Grove Park, Camberwell, London, S.
1850. ‡*Macdonald, Alexander.*
Macdonald, William, M.D., F.R.S.E., F.L.S., F.G.S., Professor of Civil and Natural History. St. Andrews, N. B.
MacDonnell, Hercules H. G. 2 Kildare-place, Dublin.
1864. ‡MacDonnell, The Very Rev. Canon. 8 Montpellier, Bath.
*M'Ewan, John. Glasgow.
1850. ‡Macfarlan, John Fletcher. Park-place, Edinburgh.
1859. ‡Macfarlane, Alexander. 73 Bon Accord-street, Aberdeen.
1855. ‡M'Farlane, Walter. Saracen Foundry, Glasgow.
1854. *Macfie, R. A. 72 Upper Parliament-street, Liverpool.
1867. *M'Gavin, Robert. Balumbie, Dundee.
1852. *M'Gee, William, M.D. 10 Donegal-square East, Belfast.
1855. ‡MacGeorge, Andrew, jun. 21 St. Vincent-place, Glasgow.
1855. ‡M'Gregor, Alexander Bennett. 19 Woodside-crescent, Glasgow.
1855. ‡MacGregor, James Watt. Wallace-grove, Glasgow.
1850. ‡*M'Gregor, Robert, M.D.*
1853. ‡*M'Gregor, Walter.*
1854. ‡*Macgregor, William.*
1859. ‡M'Hardy, David. 54 Netherkinkgate, Aberdeen.
1854. ‡*M'Ilveen, Alexander Sinclair.*
1855. ‡M'Ilwraith, H. Greenock.
Macintosh, General Alexander Fisher, K.H., F.G.S., F.R.G.S. 7 Tilney-street, Park-lane, London, W.
1859. ‡Macintosh, John. Middlefield House, Woodside, Aberdeen.
1854. *MacIver, Charles. Abercrombie-square, Liverpool.
1865. ‡*Mackeson, H. B.*
1865. ‡Mackintosh, Daniel, F.G.S. Chichester.
1855. ‡M'Kenzie, Alexander. 89 Buchanan-street, Glasgow.
*Mackenzie, James. Glentore, Scotland.
1850. ‡Mackenzie, J. W. 16 Royal Circus, Edinburgh.
Mackenzie, Rev. Kenneth. The Manse, Borrowstoness, Linlithgowshire.

Year of Election.

1865. ‡Mackenzie, Kenneth Robert Henderson, F.S.A., F.A.S.L. Seaforth House, Friern Park, near Whetstone, Middlesex.

Mackerral, William.

1859. ‡Mackie, David. Mitchell-place, Aberdeen.

1867. §Mackie, Samuel Joseph, F.G.S. 5 St. Peter's-terrace, Notting-hill, London, W.

*Mackinlay, David. Pollokshields, Glasgow.

1867. §Mackson, H. G. School House, Headingley, near Leeds.

1850. ‡Maclagan, Douglas, M.D., F.R.S.E. 28 Heriot Row, Edinburgh.

1860. ‡Maclaren, Archibald. Summertown, Oxfordshire.

1864. §MacLaren, Duncan, M.P. Newington House, Edinburgh.

1855. ‡*MacLaren, John.*

1859. ‡Maclear, Sir Thomas, F.R.S., F.R.G.S., F.R.A.S., Astronomer Royal at the Cape of Good Hope.

1862. ‡Macleod, Henry Dunning. 17 Gloucester-terrace, Camden-hill-road, London, W.

1855. ‡*M'Lintock, William.*

1861. *Maclure, John William. 2 Bond-street, Manchester.

1862. ‡Macmillan, Alexander. 1 Trinity-street, Cambridge.

1855. ‡*M'Nab, John.*

1867. §M'Neill, John. Balhousie House, Perth.

MacNeill, The Right Hon. Sir John, G.C.B., F.R.S.E., F.R.G.S. Granton House, Edinburgh.

MacNeill, Sir John, LL.D., F.R.S., M.R.I.A., Professor of Civil Engineering in Trinity College, Dublin. Mount Pleasant, Dundalk.

1854. ‡M'Nicholl, H., M.D. 42 Oxford-street, Liverpool.

1850. ‡Macnight, Alexander. 12 London-street, Edinburgh.

1859. ‡Macpherson, Rev. W. Kilmuir Easter, Scotland.

Macredie, P. B. Mure, F.R.S.E. Irvine, Ayrshire.

1854. ‡Macrorie, Dr. 126 Duke-street, Liverpool.

1852. *Macrory, Adam John. Duncairn, Belfast.

*Macrory, Edmund, M.A. 7 Fig-tree-court, Temple, London, E.C.

1855. ‡M'Tyre, William, M.D. Maybole, Ayrshire.

1855. ‡Macvicar, Rev. John Gibson, D.D. Moffat, near Glasgow.

1857. ‡*Madden, Richard R.*

Magor, J. B. Redruth, Cornwall.

1853. ‡Magrath, Rev. Folliot, A.M. Stradbally, Queen's County, Ireland.

1866. §Major, Richard H., F.S.A., F.R.G.S. British Museum, London, W.C.

*Malahide, Talbot de, The Right Hon. Lord, F.R.S. Malahide Castle, Malahide, Ireland.

1853. ‡Malan, John. Holmpton, Holderness.

*Malcolm, Frederick. Mordon College, Blackheath, London, S.E.

Malcolm, Neil. Portalloch, Lochgilphead.

1850. ‡Malcolm, R. B., M.D., F.R.S.E. 126 George-street, Edinburgh.

1863. ‡Maling, C. T. Lovaine-crescent, Newcastle-on-Tyne.

*Mallet, Robert, Ph.D., F.R.S., F.G.S., M.R.I.A. 7 Westminster Chambers, Victoria-street, Westminster, London, S.W.; and The Grove, Clapham-road, Clapham, London, S.

1857. ‡Mallet, Dr. John William. University of Alabama, U. S.

1846. ‡Manby, Charles, F.R.S., F.G.S. 79 Harley-street, London, W.

*Manchester, James Prince Lee, Lord Bishop of, F.R.S., F.G.S., F.R.G.S., F.C.P.S. Mauldreth Hall, Manchester.

1863. ‡*Mancini, Count de, Italian Consul.*

1866. §Mann, Robert James, M.D., F.R.A.S. 15 Buckingham-street, Strand, London, W.C.

Manning, The Right Rev. H.

1866. ‡Manning, John. Waverley-street, Nottingham.

Year of Election.

1864. ‡Mansel, J. C. Long Thorns, Blandford.
1865. ‡March, J. F. Fairfield House, Warrington.
1864. ‡Markham, Clements R., F.R.G.S. 21 Eccleston-square, Pimlico, London, S.W.
1852. ‡Marland, James William. Mountjoy-place, Dublin.
1863. ‡Marley, John. Mining Office, Darlington.
*Marling, Samuel S. Stanley Park, Stroud, Gloucestershire.
Marriott, John. Allerton, Liverpool.
1857. §Marriott, William. Leeds-road, Huddersfield.
1858. ‡Marriott, William Thomas. Wakefield.
1842. Marsden, Richard. Norfolk-street, Manchester.
1866. §Marsh, Dr. J. C. L. Park-row, Nottingham.
1856. ‡Marsh, M. H. Wilbury Park, Wilts.
1864. ‡Marsh, Thomas Edward Miller. 37 Grosvenor-place, Bath.
Marshall, James. Headingly, near Leeds.
1852. ‡Marshall, James D. Holywood, Belfast.
*Marshall, James Garth, M.A., F.G.S. Headingly, near Leeds.
1858. ‡Marshall, Reginald Dykes. Adel, near Leeds.
1849. *Marshall, William P. 6 Portland-road, Edgbaston, Birmingham.
1865. §Marten, E. B. 13 High-street, Stourbridge.
Martin, Rev. Francis, M.A. Trinity College, Cambridge.
**Martin, Francis P. Brouncker.*
1848. ‡Martin, Henry D. 4 Imperial Circus, Cheltenham.
Martin, Studley. 107 Bedford-street South, Liverpool.
1867. *Martin, William, Jun. Trades Lanes, Calender, N. B.
*Martindale, Nicholas. Peter-lane, Hanover-street, Liverpool.
*Martineau, Rev. James. 10 Gordon-street, Gordon-square, London.
1865. ‡Martineau, R. F. Highfield-road, Edgbaston, Birmingham.
1865. ‡Martineau, Thomas. 7 Cannon-street, Birmingham.
1847. ‡Maskelyne, Nevil Story, M.A., F.G.S., Professor of Mineralogy in the University of Oxford. British Museum, London, W.C.
1861. *Mason, Hugh. Ashton-under-Lyne.
*Mason, Thomas. York.
Massey, Hugh, Lord. Hermitage, Castleconnel, Co. Limerick.
*Mather, Daniel. 58 Mount Pleasant, Liverpool.
*Mather, John. 58 Mount Pleasant, Liverpool.
1863. *Mather, Joseph. Beech Grove, Newcastle-on-Tyne.
1865. *Mathews, G. S. Edgbaston House, Hagley-road, Birmingham.
1861. *Mathews, William, jun., M.A., F.G.S. 51 Carpenter-road, Birmingham.
1859. ‡Matthew, Alexander C. 3 Canal-terrace, Aberdeen.
1865. ‡Matthews, C. E. Waterloo-street, Birmingham.
1858. ‡Matthews, F. C. Mandre Works, Driffield, Yorkshire.
*Matthews, Henry, F.C.S. 60 Gower-street, London, W.C.
1860. ‡Matthews, Rev. Richard Brown. The Vicarage, Shalford, near Guildford.
1863. *Matthiessen, Augustus, Ph.D., F.R.S., Lecturer on Chemistry, St. Mary's Hospital. Paddington, London, W.
1857. ‡*Maughan, Rev. J. D.*
1863. ‡Maughan, Rev. W. Benwell Parsonage, Newcastle-on-Tyne.
1855. ‡Maule, Rev. Thomas, M.A. Partick, near Glasgow.
1865. *Maw, George, F.L.S., F.G.S., F.S.A. Benthall Hall, Broseley, Salop.
1863. *Mawson, John. 3 Moseley-street, Newcastle-on-Tyne.
1864. *Maxwell, Francis. Gribton, near Dumfries.
*Maxwell, James Clerk, M.A., F.R.S., L. & E. Glenlair, Dalbeattie, N.B.
1855. *Maxwell, Sir John, Bart., F.R.S. Pollok House, Renfrewshire.
1852. ‡Maxwell, John Waring. Finnebrogue, Downpatrick, Ireland.
*Maxwell, Robert Percival. Finnebrogue, Downpatrick, Ireland.

Year of Election.

1865. *May, Walter. Berkeley-street, Birmingham.
*Mayne, Rev. Charles, M.R.I.A. 22 Upper Merrion-street, Dublin.
1857. ‡*Mayne, William Annesley.*
1863. §Mease, George D. Bylton Villa, South Shields.
1863. ‡Mease, Solomon. Cleveland House, North Shields.
‡Meath, Samuel Butcher, D.D., Lord Bishop of. 13 Fitzwilliam-square West, Dublin; and Ardbraccan, Co. Meath.
1861. ‡Medcalf, William. 20 Bridgewater-place, Manchester.
1863. §Meier, R. Newcastle-upon-Tyne.
1867. §Meldrum, Charles. Mauritius.
1866. §Mello, Rev. J. M. Brampton, Chesterfield.
1854. ‡*Melly, Charles Pierre.*
1847. ‡Melville, Professor Alexander Gordon, M.D. Queen's College, Galway.
1863. ‡Melvin, Alexander. 42 Buccleuch-place, Edinburgh.
1862. §Mennell, Henry. St. Dunstan's-buildings, Great Tower-street, London, E.C.
1863. §Messent, P. T. 4 Northumberland-terrace, Tynemouth.
1847. ‡*Meyer, Charles, D.C.L.*
1847. *Michell, Rev. Richard, D.D. Magdalen Hall, Oxford.
1865. ‡Michie, Alexander. 26 Austin Friars, London, E.C.
1865. §Middlemore, William. Edgbaston, Birmingham.
1866. §Midgley, John. Colne, Lancashire.
1867. §Midgley, Robert. Colne, Lancashire.
1855. ‡Miles, Rev. Charles P., M.D., Principal of the Malta Protestant College, St. Julian's, Malta. 58 Brompton-crescent, London, S.W.
1857. ‡*Millar, George M.*
1850. ‡*Millar, James S.*
1859. ‡Millar, John. Lisburn, Ireland.
1863. §Millar, John, M.D., F.L.S., F.G.S. Bethnal House, Cambridge-road, London, N.E.
Millar, Thomas, M.A., LL.D., F.R.S.E. Perth.
1859. ‡Miller, James, jun. Greenock.
1865. ‡Miller, Rev. J. C., D.D. The Vicarage, Greenwich, London, S.E.
*Miller, Patrick, M.D. Exeter.
1861. *Miller, Robert. 30 King-street; and Whalley Range, Manchester.
1863. ‡Miller, Thomas. Righill Hall, Durham.
*Miller, William Allen, M.D., Treas. and V.P.R.S., F.C.S., Professor of Chemistry in King's College, London.
Miller, William Hallows, M.A., For. Sec. R.S., F.G.S., Professor of Mineralogy in the University of Cambridge. 7 Scroope-terrace, Cambridge.
1842. Milligan, Robert. Acacia in Randon, Leeds.
*Mills, John Robert. Bootham, York.
1851. ‡*Mills, Rev. Thomas.*
1847. ‡Milman, The Very Rev. H. H., Dean of St. Paul's, London.
1867. §Milne, James. Murie House, Errol, by Dundee.
Milne, Rear-Admiral Sir Alexander, K.C.B., F.R.S.E. Musselborough, Edinburgh.
*Milne-Home, David, M.A., F.R.S.E. Paxton House, Berwick, N.B.
1854. *Milner, William. Liverpool.
1854. *Milner, William Ralph. Wakefield, Yorkshire.
1864. ‡Milton, The Right Hon. Lord, M.P., F.R.G.S. 4 Grosvenor-square, London, W.; and Wentworth, Yorkshire.
1865. §Minton, Samuel, F.G.S. Oakham House, near Dudley.
1855. ‡Mirrlees, James Buchanan. 128 West-street, Tradeston, Glasgow.
1859. ‡Mitchell, Alexander, M.D. Old Rain, Aberdeen.
1863. ‡Mitchell, C. Walker, Newcastle-on-Tyne.
1855. ‡*Mitchell, George. Glasgow.*

Year of Election.

1862. *Mitchell, William Stephen, LL.B., F.L.S., F.G.S. Caius College, Cambridge.
1855. *Moffat, John, C.E. Ardrossan.
1854. §Moffat, Thomas, M.D., F.G.S., F.R.A.S., F.M.S. Hawarden, Chester.
1864. ‡Mogg, John Rees. High Littleton House, near Bristol.
1866. §Moggridge, Matthew, F.G.S. Richmond, Surrey.
1855. §Moir, James. 174 Gallogate, Glasgow.
1850. ‡*Moir, John, M.D.*
1861. ‡Molesworth, Rev. W. N., M.A. Spotland, Rochdale.
Mollan, John, M.D. 8 Fitzwilliam-square North, Dublin.
1852. ‡Molony, William, LL.D. Carrickfergus.
1865. §Molyneux, William, F.G.S. Branston Cottage, Burton-upon-Trent.
1853. ‡Monday, William, Hon. Sec. Hull Lit. and Phil. Soc. 6 Jarratt-street, Hull.
1860. §Monk, Rev. William, M.A., F.R.A.S. Wymington Rectory, Hyham, Ferrers, Northamptonshire.
1853. ‡Monroe, Henry, M.D. 10 North-street, Sculcoates, Hull.
1850. ‡*Monteith, Alexander E.*
Montgomery, Matthew Glasgow.
1846. ‡*Moody, T. H. C.*
1857. §Moore, Arthur. Cradley House, Clifton, Bristol.
1859. §Moore, Charles, F.G.S. 6 Cambridge-terrace, Bath.
1857. ‡Moore, Rev. Dr. Clontarf, Dublin.
Moore, John. 2 Mendiam-place, Clifton, Bristol.
*Moore, John Carrick, M.A., F.R.S., F.G.S. 113 Eaton-place, London, S.W.; and Corswall, Wigtonshire.
1866. *Moore, Thomas, F.L.S. Botanic Gardens, Chelsea, London, S.W.
1854. ‡Moore, Thomas John. Free Public Museum, Liverpool.
Moore, William D. 7 South Anne-street, Dublin.
1857. *Moore, Rev. William Prior. The College, Cavan, Ireland.
1861. ‡Morewood, Edmund. Cheam, Surrey.
Morgan, Captain Evan, R.A.
1849. ‡Morgan, William. 37 Waterloo-street, Birmingham.
Morley, George. Park-place, Leeds.
1863. ‡Morley, Samuel. Lenton-grove, Nottingham.
1865. *Morrieson, Captain Robert. Oriental Club, Hanover-square, London, W.
1861. *Morris, David. 1 Market-place, Manchester.
1845. ‡Morris, Edward, M.D. Hereford.
*Morris, Rev. Francis Orpen, B.A. Nunburnholme Rectory, Hayton, York.
Morris, Samuel, M.R.D.S. Fortview, Clontarf, near Dublin.
1861. ‡Morris, William. The Grange, Salford.
1867. §Morrison, William R. Dundee.
1863. ‡Morrow, R. J. Bentick Villas, Newcastle.
1865. §Mortimer, J. R. Fimber, Malton.
1857. §Morton, George H., F.G.S. 9 London-road, Liverpool.
1858. *Morton, Henry Joseph. Garforth House, West Garforth, near Leeds.
1847. ‡Moseley, Rev. Henry, M.A., F.R.S. Olveston Vicarage, near Bristol.
1857. ‡Moses, Marcus. 4 Westmoreland-street, Dublin.
1862. ‡*Mosheimer, Joseph.*
Mosley, Sir Oswald, Bart., D.C.L., F.L.S., F.G.S. Rolleston Hall, Burton-upon-Trent, Staffordshire.
Moss, John. Otterspool, near Liverpool.
1853. *Moss, W. H. Kingston-terrace, Hull.
1864. §Mosse, J. R. (Care of Messrs. Smith & Elder, Cornhill, London, E.C.) General Manager's Office, Mauritius Railway, Port Louis, Mauritius.

Year of
Election.

1865. ‡Mott, Charles Grey. The Park, Birkenhead.
1866. §Mott, Frederick. 18 Gallowtree Gate, Leicester.
1862. *Mouat, Frederick John, M.D., Inspector-General of Prisons, Bengal. 45 Arundel-gardens, Notting-hill, London.
1856. ‡Mould, Rev. J. G., B.D. 21 Camden-crescent, Bath.
1863. ‡Mounsey, Edward. Sunderland.
Mounsey, John. Sunderland.
1861. *Mountcastle, William Robert. 22 Dorking-terrace, Cecil-street, Greenheys, Manchester.
Mowbray, James. Combus, Clackmannan, Scotland.
1850. ‡Mowbray, J. T. 27 Dundas-street, Edinburgh.
1855. ‡Muir, William. 10 St. John-street, Adelphi, London, W.C.
Muirhead, James. 90 Buchanan-street, Glasgow.
1852. ‡*Mullan, William. Belfast.*
1857. ‡Mullins, M. Bernard, M.A., C.E. 1 Fitzwilliam-sq. South, Dublin.
Munby, Arthur Joseph. 6 Fig-tree-court, Temple, London, E.C.
1866. ‡Mundella, A. J., F.R.G.S. The Park, Nottingham.
1864. *Munro, Colonel William. United Service Club, Pall Mall, London, S.W.
1864. §Murch, Jerom. Cranwells, Bath.
*Murchison, John Henry, F.G.S. Surbiton-hill, Kingston.
1864. *Murchison, K. R. Manor House, Bathford, Bath.
*Murchison, Sir Roderick Impey, Bart., K.C.B., M.A., D.C.L. Oxon., LL.D. Camb., F.R.S., F.G.S., F.R.G.S., Hon. Mem. R.S.Ed. & R.I.A., Director-General of the Geological Survey of the United Kingdom. 16 Belgrave-square, London, S.W.
1864. ‡Murchison, Captain R. M. Caerbaden House, Cleveland-walk, Bath.
1855. ‡Murdock, James B. 195 Bath-street, Glasgow.
1858. ‡Murgatroyd, William. Bank Field, Bingley.
Murley, Rev. C. H. South Petherton, Ilminster.
1856. ‡*Murley, Stephen.*
1852. ‡Murney, Henry, M.D. 10 Chichester-street, Belfast.
1852. ‡Murphy, Joseph John. Old Forge, Dunmarry, Co. Antrim.
1850. ‡*Murray, Andrew.*
1857. ‡*Murray, B. A.*
Murray, John, F.G.S., F.R.G.S. 50 Albemarle-street, London, W.; and Newsted, Wimbledon, Surrey.
1859. ‡Murray, John, M.D. Forres, Scotland.
*Murray, John, C.E. 11 Great Queen-street, Westminster, London, S.W.
‡Murray, Rev. John. Morton, near Thornhill, Dumfriesshire.
1863. ‡Murray, William. 34 Clayton-street, Newcastle-on-Tyne.
*Murton, James. Silverdale, near Lancaster.
Musgrave, The Venerable Charles, D.D., Archdeacon of Craven. Halifax.
1861. ‡Musgrove, John, jun. Bolton.
*Muspratt, James Sheridan, Ph.D., F.C.S. College of Chemistry, Liverpool.
1865. ‡Myers, Rev. E. 17 Summerhill-terrace, Birmingham.
1845. ‡*Myers, Rev. Thomas. York.*
1859. §Mylne, Robert William, F.R.S., F.G.S., F.S.A. 21 Whitehall-place, London, S.W.
1850. ‡Myrtle, J. Y., M.D. 113 Princes-street, Edinburgh.

1850. ‡Nachot, H. W., Ph.D. 59 George-street, Edinburgh.
1842. Nadin, Joseph. Manchester.
1855. ‡Napier, James R. 22 Blythwood-square, Glasgow.
1839. *Napier, Right Honourable Joseph. 4 Merrion-square, Dublin.

Year of Election.

*_Napier, Captain Johnstone._
1855. ‡Napier, Robert. West Chandon, Gareloch, Glasgow.
Napper, James William L. Loughcrew, Oldcastle., Co. Meath.
1866. §Nash, D. W., F.S.A., F.L.S. 13 Bays Hill-terrace, Cheltenham.
1850. *Nasmyth, James. Penge Hurst, Kent.
Nasmyth, Robert, F.R.S.E. 5 Charlotte-square, Edinburgh.
1864. ‡Natal, William Colenso, Lord Bishop of.
1860. ‡Neate, Charles, M.A., M.P. Oriel College, Oxford.
1867. §Neaves, The Right Hon. Lord. Edinburgh.
1850. ‡_Necker, Theodore. Geneva._
1845. ‡Neild, Arthur. Ollernshaw, Whaleybridge, by Stockport.
1853. ‡Neill, William, Governor of Hull Jail. Hull.
Neilson, James B.
Neilson, Robert. Woolton-hill, Liverpool.
1855. ‡Neilson, Walter. 172 West George-street, Glasgow.
1865. ‡Neilson, W. Montgomerie. Glasgow.
1846. ‡_Neison, F. G. P._
1861. *Nelson, William. Scotland Bridge, Manchester.
1849. ‡Nesbit, C. J. Lower Kennington-lane, London, .
Ness, John. Helmsley, near York.
1866. *Nevill, Rev. Samuel Tarratt, B.A., F.L.S. Shelton Rectory, Manchester.
1861. ‡Nevill, Thomas Henry. 17 George-street, Manchester.
1857. ‡Neville, John, C.E., M.R.I.A. Dundalk, Ireland.
1852. ‡Neville, Parke, C.E. Town Hall, Dublin.
1842. New, Herbert. Evesham, Worcestershire.
Newall, Henry. Hare-hill, Littleborough, Lancashire.
*Newall, Robert Stirling. Gateshead-upon-Tyne.
1867. §Newbegin, James. Norwich.
Newberry, Rev. Thomas, M.A. The Rectory, Hinton, Ilminster, Somerset.
Newbigging, P. S. K., M.D. Edinburgh.
1866. *Newdegate, Albert L. 11 Stanhope-place, Hyde Park, London, W.
1854. *Newlands, James. 2 Clare-terrace, Liverpool.
1842. *Newman, Francis William 1 Dover-place, Clifton, Bristol.
*Newman, William. Darley Hall, near Barnsley, Yorkshire.
1863. *Newmarch, William, F.R.S. Heath View, West Side, Clapham Common, London, S.
1853. ‡Newmarch, William, Secretary to Globe Insurance, Cornhill, London.
1866. *Newmarch, William Thomas. Heath View, West Side, Clapham-common, London, S.
1858. ‡Newsome, Thomas. Park-road, Leeds.
1860. *Newton, Alfred, M.A., F.L.S., Professor of Zoology in the University of Cambridge Magdalen College, Cambridge.
1865. ‡Newton, Thomas Henry Goodwin. Clopton House, near Stratford-on-Avon.
1867. §Nicholl, Dean of Guild. Dundee.
1867. §Nicholl, Donald. Oakland Hall, Kilburn, London, N.W.
Nicholl, Iltyd, F.L.S. Uske, Monmouthshire.
1848. ‡Nicholl, W. H. Uske, Monmouthshire.
1866. §Nicholson, Sir Charles, Bart., D.C.L., LL.D., M.D., F.G.S., F.R.G.S. 26 Devonshire Place, Portland-place, London, W.
*Nicholson, Cornelius, F.G.S. Welfield, Muswell-hill, London, N.
1861. *Nicholson, Edward. 28 Princess-street, Manchester.
1867. §Nicholson, Henry Alleyne, D.Sc., F.G.S. Penrith.
*Nicholson, John A., A.M., M.B., Lic. Med., M.R.I.A. Balrath, Kells, Co. Meath.
1858. *Nicholson, William Nicholson. Roundhay Park, Leeds.

Year of Election.

1850. ‡Nicol, J., Professor of Natural History in Marischal College, Aberdeen.
1851. ‡*Nicolay, Rev. C. G.*
1867. §Nimmo, Dr. Matthew, L.R.C.S.E. Nethergate, Dundee.
1856. ‡*Niven, Rev. James.*
Niven, Ninian. Clonturk Lodge, Drumcondra, Dublin.
1864. ‡Noad, Henry M., Ph.D., F.R.S., F.C.S. 72 Hereford-road, Bayswater, London, W.
1854. ‡Noble, Matthew. 13 Bruton-street, Bond-street, London W.
1863. *Noble, Captain William R. Elswick Works, Newcastle-on-Tyne.
1860. *Nolloth, Matthew S., Captain R.N., F.R.G.S. United Service Club, London, S.W.
1859. ‡Norfolk, Richard. Messrs. W. Rutherford and Co., 14 Canada Dock, Liverpool.
1863. §Norman, Rev. Alfred Merle, M.A. Houghton-le-Spring, Co. Durham.
Norreys, Sir Denham Jephson, Bart. Mallow Castle, Co. Cork.
Norris, Charles. St. John's House, Halifax.
1865. §Norris, Dr. Richard. 2 Walsall-road, Birchfield, Birmingham.
1866. ‡North, Thomas. Cinder Hill, Nottingham.
Northampton, Charles Douglas, The Right Hon. Marquis of. 145 Piccadilly, London, W.; and Castle Ashby, Northamptonshire.
1860. ‡Northcote, A. Beauchamp, F.C.S. Queen's College, Oxford.
*Northwick, The Right Hon. Lord, M.A., F.G.S. 22 Park-street, Grosvenor-square, London, W.
1851. ‡Notcutt, S. A. Westgate-street, Ipswich.
1861. ‡Noton, Thomas. Priory House, Oldham.
1851. ‡Nourse, William E. C., F.R.C.S. West Cowes, Isle of Wight.
Nowell, John. Farnley Hall, Huddersfield.
1857. ‡*Nuling, Alfred.*
1858. §Nunnerley, Thomas, F.R.C.S.E. Leeds.
1859. ‡Nuttall, James. Wellfield House, Todmorden.

O'Beirne, James, M.D. 11 Lower Gardiner-street, Dublin.
O'Brien, Baron Lucius. Dromoland, Newmarket-on-Fergus, Ireland.
O'Callaghan, George. Tallas, Co. Clare.
1858. *O'Callaghan, Patrick, LL.D., D.C.L. 16 Clarendon-square, Leamington.
Odgers, Rev. William James. Sion-hill, Bath.
1858. *Odling, William, M.B., F.R.S., Sec. Chem. Soc., Professor of Chemistry in the Medical School of St. Bartholomew's Hospital. Sydenham-road, Croydon, Surrey.
1857. ‡O'Donnavan, William John. 2 Cloisters, Temple, Dublin.
1866. ‡Ogden, James. Woodhouse, Loughborough.
1859. ‡Ogilvie, C. W. Norman. Baldovan House, Dundee.
*Ogilvie, George, M.D., Lecturer on the Institutes of Medicine in Marischal College, Aberdeen.
1863. §Ogilvy, G. R. Inverquharty, N. B.
1863. ‡Ogilvy, Sir John, Bart. Inverquharity, N. B.
1863. ‡*Ogle, Rev. E. C.*
*Ogle, William, M.D., M.A. Derby.
1859. ‡Ogston, Francis, M.D. 18 Adelphi-court, Aberdeen.
1837. ‡O'Hagan, John. 20 Kildare-street, Dublin.
1862. ‡O'Kelly, Joseph, M.A. 51 Stephen's Green, Dublin.
1857. ‡O'Kelly, Matthias J. Dalkey, Ireland.
1853. §Oldham, James, C.E. Austrian Chambers, Hull.
1857. *Oldham, Thomas, M.A., LL.D., F.R.S., F.G.S., M.R.I.A., Director of the Geological Survey of India. Calcutta.
1860. ‡O'Leary, Professor Purcell, M.A. Sydney-place, Cork.

Year of Election.

1863. ‡Oliver, D. Richmond, Surrey.
*Ommanney, Erasmus, Rear-Admiral, C.B., F.R.A.S., F.R.G.S. 6 Talbot-square, Hyde-park, London, W.; and United Service Club, Pall Mall, London, S.W.
1867. §Orchar, James G. 9 William-street, Forebank, Dundee.
1847. **Orlebar, A. B., M.A.*
1842. Ormerod, George Wareing, M.A., F.G.S. Chagford, Exeter.
1861. ‡Ormerod, Henry Mere. Clarence-street, Manchester; and 11 Woodland-terrace, Cheetham-hill, Manchester.
1858. ‡Ormerod, T. T. Brighouse, near Halifax.
Orpen, John H., LL.D., M.R.I.A. (*Local Treasurer.*) 58 Stephen's Green, Dublin.
1854. ‡Orr, Sir Andrew. Blythwood-square, Glasgow.
1865. ‡Osborne, E. C. Carpenter-road, Edgbaston, Birmingham.
*Osler, A. Follett, F.R.S. South Bank, Edgbaston, Birmingham.
1865. *Osler, Henry F. Portland-road, Edgbaston, Birmingham.
**Ossalinski, Count.*
1854. §Outram, Thomas. Greetland, near Halifax.
Ovenend, Wilson. Sharrow Head, Sheffield.
Overston, Samuel Jones Lloyd, Lord, F.G.S. 22 Norfolk-street, Park-lane, London, W.; and Wickham Park, Bromley.
1857. ‡Owen, James H. Park House, Sandymount, Co. Dublin.
Owen, Richard, M.D., D.C.L., LL.D., F.R.S., F.L.S., F.G.S., Hon. M.R.S.E., Director of the Natural History Department, British Museum. Sheen Lodge, Mortlake, Surrey, S.W.
1863. *Ower, Charles. 11 Craigie-terrace, Dundee.
Oxford, Samuel Wilberforce, D.D., Lord Bishop of, F.R.S., F.S.A., F.R.G.S. 26 Pall Mall, London, S.W.; and Cuddesdon Palace, Wheatley, Oxon.

1855. ‡Pagan, John M., M.D. West Regent-street, Glasgow.
1850. ‡Pagan, Samuel Alexander, M.D., F.R.S.E. Edinburgh.
1867. §Pagan, Wiliam. Clayton, by Cupar, Fifeshire.
1859. ‡Page, David, LL.D., F.R.S.E., F.G.S. 44 Gilmore-place, Edinburgh.
1863. §Paget, Charles. Ruddington Grange, near Nottingham.
1845. ‡Paget, George E., M.D. Cambridge.
1847. ‡*Pakington, J. S., B.A.*
1863. ‡Palmer, C. M. Whitley Park, near Newcastle-on-Tyne.
1866. §Palmer, H. Goldsmith-street, Nottingham.
*Palmer, Sir William, Bart. Whitchurch-Canonicorum, Dorset.
1866. ‡Palmer, William. Canal-street, Nottingham.
Palmes, Rev. William Lindsay, M.A. The Vicarage, Hornsea, Hull.
1854. ‡Pare, William, F.S.S. Seville Iron Works, Dublin.
1857. *Parker, Alexander, M.R.I.A.. William-street, Dublin.
*Parker, Charles Stewart. Liverpool.
1863. ‡Parker, Henry. Low Elswick, Newcastle-on-Tyne.
1863. ‡Parker, Rev. Henry. Idlerton Rectory, Low Elswick, Newcastle-on-Tyne.
Parker, Joseph, F.G.S. Upton Chaney, Bitton, near Bristol.
1845. ‡Parker, J. W., jun. Strand, London, W.C.
Parker, Richard. Dunscombe, Cork.
Parker, Rev. William. Saham, Norfolk.
1865. *Parker, Walter Mantel. Warren-corner House, near Farnham, Surrey.
1853. ‡Parker, William. Thornton-le-Moor, Lincolnshire.
1861. ‡*Parkes, Alexander.*
1865. *Parkes, Samuel Hickling. 5 St. Mary's-row, Birmingham.
1864. §Parkes, William. 14 Park-street, Westminster, London, S.W.
1859. ‡Parkinson, Robert, Ph.D. Bradford, Yorkshire.

Year of
Election.

1863. ‡Parland, Captain. Stokes Hall, Jesmond, Newcastle-on-Tyne.
Parnell, E. A.
1862. §Parnell, John, M.A. Hadham House, Upper Clapton, London, N.E.
Parnell, Richard, M.D., F.R.S.E. 7 James's-place, Leith, Edinburgh.
1854. ‡Parr, Alfred, M.D. New Brighton, Cheshire.
Partington, James Edge.
Partridge, Richard, F.R.S., Professor of Anatomy to the Royal Academy of Arts, and to King's College, London. 17 New-street, Spring-gardens, London, S.W.
1865. *Parsons, Charles Thomas. Edgbaston, Birmingham.
1855. ‡Paterson, William. 100 Brunswick-street, Glasgow.
1861. ‡Patterson, Andrew. Deaf and Dumb School, Old Trafford, Manchester.
1863. ‡Patterson, H. L. Scott's House, near Newcastle-on-Tyne.
1867. §Patterson, James. Kinnettles, Dundee.
1863. ‡Patterson, John. 16 Bloomfield-terrace, Gateshead-on-Tyne.
1839. *Patterson, Robert, F.R.S. (*Local Treasurer.*) 6 College-square North, Belfast.
1867. §Patterson, Samuel R. 50 Lombard-street, London, E.C.
1863. ‡Pattinson, William. Felling, near Newcastle-on-Tyne.
1864. ‡Pattison, Dr. T. H. Edinburgh.
1863. §Paul, Benjamin H., Ph.D. 8 Gray's Inn-square, London, W.C.
Paul, Henry.
1863. ‡Pavy, Frederick William, M.D., F.R.S., Lecturer on Physiology and Comparative Anatomy and Zoology at Guy's Hospital. 35 Grosvenor-street, London, W.
1864. ‡Payne, Edward Turner. 3 Sydney-place, Bath.
1851. ‡Payne, Joseph. 4 Kildare Gardens, Bayswater, London, W.
1866. ‡Payne, Joseph Frank. 4 Kildare-gardens, Bayswater, London, W.
1847. §Peach, Charles W. 30 Haddington-place, Leith-walk, Edinburgh.
1863. §Peacock, Richard Atkinson. St. Heliers, Jersey.
*Pearsall, Thomas John, F.C.S. Birkbeck Literary and Scientific Institution, Southampton-buildings, Chancery-lane, London, E.C.
1854. ‡Pearson, J. A. Woolton, Liverpool.
1853. ‡Pearson, Robert H. 1 Prospect House, Hull.
Pearson, Rev. Thomas, M.A.
1863. §Pease, H. F. Brinkburn, Darlington.
1852. ‡Pease, Joseph Robinson. Hesslewood.
1863. ‡Pease, Joseph W. Woodlands, Darlington.
1863. ‡Pease, J. W. Newcastle-on-Tyne.
1858. *Pease, Thomas, F.G.S. Cote Bank, Westbury-on-Trym, near Bristol.
Peckitt, Henry. Carlton Husthwaite, Thirsk, Yorkshire.
1855. *Peckover, Alexander, F.R.G.S. Wisbeach, Cambridgeshire.
*Peckover, Algernon, F.L.S. Wisbeach, Cambridgeshire.
*Peckover, Daniel. Woodhall, Calverley, Leeds.
*Peckover, William, F.S.A. Wisbeach, Cambridgeshire.
*Pedler, Lieutenant-Colonel Philip Warren. Mutley House, near Plymouth.
*Peel, George. Soho Iron Works, Manchester.
1861. *Peile, George, jun. Shotley Bridge, near Gateshead-on-Tyne.
1861. *Peiser, John. Barnfield House, Oxford-street, Manchester.
1865. ‡Pemberton, Oliver. 18 Temple-row, Birmingham.
1861. *Pender, John. Mount-street, Manchester.
1856. §Pengelly, William, F.R.S., F.G.S. Lamorna, Torquay.
1855. ‡Penny, Frederick, Professor of Chemistry in the Andersonian University, Glasgow.
1849. ‡Pentland, J. B. 5 Ryder-street, St. James's, London, S.W.

Year of Election.

1845. ‡Percy, John, M.D., F.R.S., F.G.S., Professor of Metallurgy in the Government School of Mines. Museum of Practical Geology, Jermyn-street, S.W.; and 1 Gloucester-crescent, Hyde-park, London.
1856. ‡*Perkins, A. M.*
1861. ‡Perkins, Rev. George. St. James's View, Dickenson-road, Rusholme, near Manchester.
Perkins, Rev. R. B., D.C.L. Wotton-under-Edge, Gloucestershire.
1864. *Perkins, V. R. Wotton-under-Edge.
1867. §Perkins, William. 6 Russell-place, Fitzroy-square, London, W.
1861. ‡Perring, John Shae. 104 King-street, Manchester.
Perry, The Right Rev. Charles, M.A., Bishop of Melbourne, Australia.
*Perry, Rev. S. G. F., M.A. Tottington Parsonage, near Bury.
*Peters, Edward. Temple-row, Birmingham.
1856. *Petit, Rev. John Louis. 9 New-square, Lincoln's Inn, London, W.C.
1854. ‡Petrie, James, M.D. 13 Upper Parliament-street, Liverpool.
1861. *Petrie, John. Rochdale.
1846. ‡Petrie, William. Ecclesbourne Cottage, Woolwich.
Pett, Samuel, F.G.S. 7 Albert-road, Regent's Park, London, N.W.
Peyton, Abel.
1867. §Phayre, Colonel Sir Arthur. United Service Club, Pall Mall, London, S.W.
1857. ‡*Phayre, George.*
1845. ‡Phelps, Rev. Robert, D.D. Cambridge.
1863. *Phené, John Samuel, F.R.G.S. 34 Oakley-street, Chelsea, London, S.W.
1853. *Philips, Rev. Edward. The Bank, near Cheadle, Staffordshire.
1853. *Philips, Herbert. 35 Church-street, Manchester.
*Philips, Mark. The Park, near Manchester.
1863. ‡Philipson, Dr. 1 Saville Row, Newcastle-on-Tyne.
1856. *Phillipps, Sir Thomas, Bart., M.A., F.R.S. Middle-hill, near Broadway, Worcestershire.
1859. *Phillips, Major-General Sir Frowell. United Service Club, Pall Mall, London.
1850. ‡*Phillips, George.*
1862. ‡Phillips, Rev. George, D.D., Queen's College, Cambridge.
*Phillips, John, M.A., LL.D., D.C.L., F.R.S., F.G.S., Professor of Geology in the University of Oxford. Museum House, Oxford.
1859. ‡*Phillips, Major J. Scott.*
Philpott, The Right Rev. Henry, D.D., Lord Bishop of Worcester.
1864. §Pickering, William. 3 Bridge-street, Bath.
1861. ‡Pickstone, William. Radcliff Bridge, near Manchester.
1856. ‡Pierson, Charles. 3 Blenheim-parade, Cheltenham.
Pigott, J. H. Smith. Brockley Hall, Bristol.
1865. ‡Pike, L. Owen. 25 Carlton-villas, Maida Vale, London, W.
*Pike, Ebenezer. Besborough, Cork.
1864. ‡Pilditch, Thomas. Portway House, Frome.
1857. ‡Pilkington, Henry M., M.A., Q.C. 35 Gardiner's-place, Dublin.
1863. *Pim, Commander Bedford C. T., R.N., F.R.G.S. Junior United Service Club, London, S.W.
Pim, George, M.R.I.A. Brennan's Town, Cabinteely, Dublin.
Pim, Jonathan. Harold's Cross, Dublin.
Pim, William H. Monkstown, Dublin.
1861. ‡Pincoffs, Simon. Crumpsall Lodge, Cheetham-hill, Manchester.
1859. ‡Pirrie, William, M.D. 238 Union-street West, Aberdeen.
1866. §Pitcairn, David. Dudhope House, Dundee.

Year of Election.

1864. ‡Pitt, R. 5 Widcomb-terrace, Bath.
1865. ‡Plant, Thomas L. Camp-hill, and 33 Union-street, Birmingham.
1863. *Platt, John. Werneth Park, Oldham, Lancashire.
1867. §Playfair, Lieut.-Colonel, H.M. Consul, Algeria.
1842. Playfair, Lyon, C.B., Ph.D., LL.D., F.R.S. L. & E., V.P.C.S., Professor of Chemistry in the University of Edinburgh. 14 Abercromby-place, Edinburgh.
Plumptre, Charles Frederick, D.D., Master of University College, Oxford. University College, Oxford.
1857. ‡Plunkett, Thomas. Ballybrophy House, Borris-in-Ossory, Ireland.
1861. *Pochin, Henry Davis, F.C.S. Oakfield House, Salford.
1847. ‡Pococke, Rev. N., M.A. Queen's College, Oxford.
*Pollexfen, Rev. John Hutton, M.A., Rector of St. Runwald's, Colchester.
Pollock, A. 52 Upper Sackville-street, Dublin.
1862. *Polwhele, Thomas Roxburgh, M.A. Polwhele, Truro, Cornwall.
*Pontey, Alexander. Plymouth.
1854. ‡*Poole, Braithwaite.*
*Poppelwell, Matthew. Rosella-place, Tynemouth.
Porter, Rev. Charles, D.D.
*Porter, Henry John Ker. Alston Cottage, Brampton, Huntingdon.
1846. ‡*Porter, John.*
1866. §Porter, R. Beeston, Nottingham.
Porter, Rev. T. H., D.D. Desertcreat, Co. Armagh.
1863. ‡Potter, D. M. Cramlington, near Newcastle-on-Tyne.
*Potter, Edmund, F.R.S. 22 Princes Gardens, Hyde Park, London, W.
Potter, Henry Glassford, F.L.S., F.G.S. Reform Club, London, S.W.; Jesmond High-terrace, Newcastle-on-Tyne.
Potter, Richard, M.A., F.C.P.S. Ampthill-square, Hampstead-road, London, N.W.
1842. Potter, Thomas. George-street, Manchester.
Potter, William. 34 Falkner-street, Liverpool.
1863. ‡Potts, James. 52½ Quayside, Newcastle-on-Tyne.
1857. *Pounden, Captain Londsdale, F.R.G.S. Junior United Service Club, London, S.W.; and Brownswood, Co. Wexford.
Powell, Rev. Dr. Madras.
1851. ‡*Power, David.*
1857. ‡Power, Sir James, Bart. Edermine, Enniscorthy, Ireland.
1867. §Powrie, James. Reswallie, Forfar.
1859. ‡*Poynter, John. Glasgow.*
1855. *Poynter, John E. Clyde Neuck, Uddingstone, Hamilton, Scotland.
1846. ‡*Poyter, Thomas.*
1864. ‡Prangley, Arthur. 2 Burlington-buildings, Redland, Bristol.
Pratt, Archdeacon, M.A., F.C.P.S. Calcutta.
1864. *Prentice, Manning. Stowmarket, Suffolk.
Prest, Edward, Archdeacon. The College, Durham.
Prest, John. Blossom-street, York.
*Prestwich, Joseph, F.R.S., Treas. G.S. 2 Suffolk-lane, London, E.C.; and 10 Kent-terrace, Regent's Park-road, London, N.W.
*Pretious, Thomas. H.M. Dockyard, Devonport.
1846. ‡Priaulx, Nicholas M. 9 Brunswick-place, Southampton.
1856. *Price, Rev. Bartholomew, M.A., F.R.S., F.R.A.S., Sedleian Professor of Natural Philosophy in the University of Oxford. 11 St. Giles's-street, Oxford.
Price, J. T. Neath Abbey, Glamorganshire.
1865. ‡Prideaux, J. S. 209 Piccadilly, London, W.
1864. *Prior, R. C. A., M.D. Halse House, Taunton.
1865. *Prichard, Thomas, M.D. Avington Abbey, Northampton.

Year of Election.

1835. *Pritchard, Andrew. 87 St. Paul's-road, Highbury, London, N.
1846. *Pritchard, Rev. Charles, M.A., F.R.S., F.R.A.S., F.G.S. Hursthill, Freshwater, Isle of Wight.
1863. ‡Procter, R. S. Summerhill-terrace, Newcastle-on-Tyne.
Proctor, Thomas. Elmsdale House, Clifton Down, Bristol.
Proctor, William. Rialto Villa, Redland Park, Clifton, Bristol.
1858. ‡Proctor, William, M.D., F.C.S. 24 Petergate, York.
1863. *Prosser, John. 38 Cumberland-road, Newcastle-on-Tyne.
Protheroe, Captain W. G. B. Dolewilim, St. Clair's, Carnarvonshire.
1863. ‡Proud, Joseph. South Hetton, Newcastle-on-Tyne.
1849. ‡Proud, Thomas Aston. Villa-road, Handsworth.
*Prower, Rev. J. M., M.A. Swindon, Wiltshire.
1865. §Prowse, Albert P. Whitchurch Villa, Mannamead, Plymouth.
1854. ‡*Puckle, Hale G.*
1864. ‡Pugh, John. Aberdovey, Shrewsbury.
1859. ‡Pugh, William. Coalport, Shropshire.
1867. §Puller, John. 4 Leonard Bank, Perth.
1867. §Puller, Robert. 4 Leonard Bank, Perth.
1854. ‡*Pulsford, James.*
1842. *Pumphrey, Charles. 34 Frederick-street, Edgbaston, Birmingham.
Punnett, Rev. John, M.A., F.C.P.S. St. Earth, Cornwall.
1852. ‡Purdon, Thomas Henry, M.D. Belfast.
1860. ‡Purdy, Frederick, F.S.S., Principal of the Statistical Department of the Poor Law Board, Whitehall, London. Victoria-road, Kensington, London, W.
1866. ‡Purser, John. Queen's College, Belfast.
1860. *Pusey, S. E. Bouverie. Pusey, Farringdon.
1861. *Pyne, Joseph John. 63 Piccadilly, Manchester.

1860. ‡Radcliffe, Charles Bland, M.D. 4 Henrietta-street, Cavendish-square, London, W.
*Radford, William, M.D. Sidmount, Sidmouth.
1861. ‡Rafferty, Thomas. 13 Monmouth-terrace, Rusholme, Manchester.
1854. ‡Raffles, Thomas Stamford. 21 Canning-street, Liverpool.
1859. ‡Rainey, George, M.D. 17 Golden-square, Aberdeen.
1855. ‡Rainey, Harry, M.D. 10 Moore-place, Glasgow.
1864. ‡Rainey, James T. 8 Widcomb-crescent, Bath.
Rake, Joseph. Charlotte-street, Bristol.
1863. §Ramsay, Alexander, jun., F.G.S. 45 Norland-square, Notting Hill, London, W.
1845. ‡Ramsay, Andrew Crombie, F.R.S., F.G.S., Local Director ofthe Geological Survey of Great Britain, and Professor of Geology in the Government School of Mines. Museum of Practical Geology, Jermyn-street, London, S.W.
1863. ‡Ramsay, D. R. Wallsend, Newcastle-on-Tyne.
1867. §Ramsay, James, Jun. Dundee.
1861. ‡Ramsay, John. Kildalton, Argyleshire.
1867. *Ramsay, W. F., M.D. 15 Somerset-place, Portman-square, London, W.
1845. ‡*Ramsay, William.*
1858. *Ramsbotham, John Hodgson, M.D. 16 Park-place, Leeds.
*Rance, Henry. Cambridge.
Rand, John. Wheatley-hill, Bradford, Yorkshire.
1865. ‡Randel, J. 50 Vittoria-street, Birmingham.
1860. ‡Randall, Thomas. Grandepoint House, Oxford.
1855. ‡Randolph, Charles. Pollockshiels, Glasgow.
1847. ‡Randolph, Captain C. G. Wrotham, Kent.
860. *Randolph, Rev. Herbert, M.A. Marcham, near Abingdon.

Year of Election.

Randolph, Rev. John Honywood, F.G.S. Sanderstead, Croydon.
Ranelagh, the Right-Hon. Lord. 7 New Burlington-street, Regent-street, London, W.
1850. §Rankine, William John Macquorn, LL.D., F.R.S. L. & E., Regius Professor of Civil Engineering and Mechanics in the University of Glasgow. 59 St. Vincent-street, Glasgow.
1861. §Ransome, Arthur, M.A. Bowdon, Manchester.
1851. ‡Ransome, Frederick. Lower Brook-street, Ipswich.
1851. ‡*Ransome, George.*
1849. *Ransome, Robert. Iron Foundry, Ipswich.
Ransome, Thomas. 34 Princess-street, Manchester.
1863. §Ransome, Dr. W. H. Low Pavement, Nottingham.
Rashleigh, Jonathan. 3 Cumberland-terrace, Regent's Park, London, N.W.
*Ratcliff, Charles, F.L.S., F.G.S., F.S.A., F.R.G.S. Wyddrington, Edgbaston, Birmingham.
1864. §Rate, Rev. John, M.A. Lapley Vicarage, Penkridge, Staffordshire.
Rathbone, Theodore W. Allerton Priory, near Liverpool.
Rathbone, William. 7 Water-street, Liverpool.
1863. ‡Rattray, W. St. Clement's Chemical Works, Aberdeen.
1848. ‡Ravenshaw, E. C. Athenæum Club, London, S.W.
Rawdon, William Frederick M.D. Bootham York.
*Rawlins, John. Llewesog Hall, Denbighshire.
1866. *Rawlinson, George, M.A., Camden Professor of Ancient History in the University of Oxford. Oxford.
1855. *Rawlinson, Major-General Sir Henry C., K.C.B.,M.P., LL.D., F.R.S., F.R.G.S. 1 Hill-street, Berkeley-square, London, W.
Rawson, Rawson William, F.R.G.S.
*Rawson, Thomas William. Saville Lodge, Halifax.
1865. §Rayner, Henry. Lonsdale Villa, Smethwick, Birmingham.
1845. ‡*Read, Joseph, M.D.*
1852. ‡Read, Thomas, M.D. Donegal-square West, Belfast.
1865. §Read, William. Albion House, Epworth, Bawtry.
1858. ‡Read, William Henry. Chapel Allerton, near Leeds.
*Read, W. H. Rudstone, M.A., F.L.S. Hayton, near Pocklington, Yorkshire.
*Reade, Rev. Joseph Bancroft, M.A., F.R.S. Bishopbourne Rectory, Canterbury.
1862. *Readwin, Thomas Allison, F.G.S. Stretford, near Manchester.
1864. §Reddie, James, Hon. Sec. to the Victoria Institute or Philosophical Society of Great Britain. Bridge House, Hammersmith, London.
1852. *Redfern, Professor Peter, M.D. 4 Lower-crescent, Belfast.
1863. ‡Redmayne, Giles. 20 New Bond-street, London, W.
1863. ‡Redmayne, R. R. 12 Victoria-terrace, Newcastle-on-Tyne.
Redwood, Isaac. Cae Wern, near Neath, South Wales.
1861. *Reé, H. P. 27 Faulkner-street, Manchester.
1861. ‡Reed, Edward J., Chief Constructor of the Navy. Admiralty, Whitehall, London, S.W.
1854. ‡*Reid, David Boswell, M.D.*
1850. ‡Reid, William, M.D. Cuivie, Cupar, Fife.
1849. ‡*Reid, Major-General Sir William.*
1863. §Renals, E. 'Nottingham Express' Office, Nottingham.
1863. ‡Rendel, G. Benwell, Newcastle-on-Tyne.
Rennie, Sir John, Knt., F.R.S., F.G.S., F.S.A., F.R.G.S. 32 Charing Cross, London, W.C.
1860. ‡Rennison, Rev. Thomas, M.A. Queen's College, Oxford.
**Renny, Lieutenant H. L., R.E. Montreal.*
1867. §Renny, W. W. 8 Douglas-terrace, Broughty Ferry, Dundee.

Year of Election.

1858. §Reynolds, Richard, F.C.S. 13 Briggate, Leeds.
1849. ‡Reynolds, Thomas F., M.D. 14 Lansdowne-terrace, Cheltenham.
Reynolds, William, M.D. Coeddu, near Mold, Flintshire.
1850. ‡Rhind, William. 121 Princes-street, Edinburgh.
1858. *Rhodes, John. Leeds.
1847. ‡*Ricardo, M. Brighton.*
1863. §Richardson, Benjamin Ward, M.A., M.D., F.R.S. 12 Hinde-street Manchester-square, London, W.
1861. §Richardson, Charles. Almondbury, Bristol.
1863. *Richardson, Edward, jun. South Ashfield, Newcastle-on-Tyne.
Richardson, James. Glasgow.
1854. ‡*Richardson, John. Hull.*
1863. ‡Richardson, John W. South Ashfield, Newcastle-on-Tyne.
Richardson, Thomas. Glasgow.
Richardson, Thomas. Montpelier-hill, Dublin.
Richardson, William. Micklegate, York.
1861. §Richardson, William. 4 Edward-street, Werneth, Oldham.
Richardson, Rev. William.
1861. ‡Richson, Rev. Canon, M.A. Shakespeare-street, Ardwick, Manchester.
1863. ‡Richter, Otto, Ph.D. Bathgate, Linlithgowshire.
*Riddell, General Charles James Buchanan, C.B., F.R.S. Athenæum Club, Pall Mall, London, S.W.
1861. *Riddell, H. B. The Palace, Maidstone.
1859. ‡Riddell, Rev. John. Moffat by Beatlock, N. B.
1861. *Rideout, William J. Farnworth, near Manchester.
1862. ‡Ridgway, Henry Akroyd, B.A. Bank Field, Halifax.
1861. §Ridley, John. 19 Belsize-park, Hampstead, London, N.W.
1863. ‡Ridley, Samuel. 7 Regent's-terrace, Newcastle-on-Tyne.
1863. *Rigby, Samuel. Bruch Hall, Warrington.
*Rinder, Miss. Gledhow Grove, Leeds.
1860. §Ritchie, George Robert. 4 Watkyn-Terrace, Coldharbour-lane, Camberwell, London.
1867. §Ritchie, John. Fleuchar Craig, Dundee.
1855. ‡Ritchie, Robert, C.E. 14 Hill-street, Edinburgh.
1867. §Ritchie, William. Emslea, Dundee.
1853. ‡Rivay, John V. C. 19 Cowley-street, London, S.W.
1854. ‡Robberds, Rev. John, B.A. Liverpool.
1855. ‡Roberton, James. Gorbals Foundry, Glasgow.
Roberton, John. Oxford-road, Manchester.
1859. ‡Roberts, George Christopher. Hull.
1859. ‡Roberts, Henry, F.S.A. Athenæum Club, London, S.W.
1854. ‡*Roberts, John.*
1853. ‡Roberts, John Francis. 10 Adam-street, Adelphi, London, W.C.
1857. ‡Roberts, Michael, M.A. Trinity College, Dublin.
*Roberts, William P. 50 Ardwick Green, Manchester.
1867. §Robertson, David. Union Grove, Dundee.
1859. ‡Robertson, Dr. Andrew. Indego, Aberdeen.
1866. §Robertson, A. Stuart, M.D., F.R.G.S. Horwick, Bolton, Lancashire.
1866. ‡Robertson, William Tindal, M.D. Nottingham.
1863. ‡*Robinson, Dr.*
1861. ‡Robinson, Enoch. Dukinfield, Cheshire.
1852. ‡Robinson, Rev. George. Tartaragham Glebe, Loughgall, Ireland.
1864. ‡Robinson, George Augustus. Widcomb-hill, Bath.
1859. ‡Robinson, Hardy. 156 Union-street, Aberdeen.
1860. ‡*Robinson, Professor H. D.*
*Robinson, H. Oliver. 16 Park-street, Westminster, London, S.W.

Year of Election.

1866. ‡Robinson, John. Museum, Oxford.
1861. ‡Robinson, John. Atlas Works, Manchester.
1863. ‡Robinson, J. H. Cumberland-row, Newcastle-on-Tyne.
1855. ‡Robinson, M. E. 116 St. Vincent-street, Glasgow.
1860. ‡Robinson, Admiral Robert Spencer. 61 Eaton-place, London, S.W.
Robinson, Rev. Thomas Romney, D.D., F.R.S., F.R.A.S., M.R.I.A., Director of the Armagh Observatory. Armagh.
1863. ‡Robinson, T. W. U. Houghton-le-Spring, Durham.
1863. **Robson, James.*
*Robson, Rev. John, D.D. Glasgow.
1855. ‡Robson, Neil, C.E. 127 St. Vincent-street, Glasgow.
1845. ‡*Rocow, Tattersall Thomas.*
1851. ‡Rodwell, William. Woodlands, Holbrook, Ipswich.
Roe, Henry, M.R.I.A. 2 Fitzwilliam-square East, Dublin.
1866. ‡Roe, Thomas. Grove Villas, Sitchurch.
1846. ‡Roe, William Henry. Portland-terrace, Southampton.
1861. §Rofe, John, F.G.S. Queen-street, Lancaster.
1860. ‡Rogers, James E. Thorold. Beaumont-street, Oxford.
1867. §Rogers, James S. Rosemill, by Dundee.
*Roget, Peter Mark, M.D., F.R.S. 18 Upper Bedford-place, Russell-square, London, W.C.
1859. ‡Rolleston, George, M.A., M.D., F.R.S., F.L.S., Professor of Anatomy and Physiology in the University of Oxford. 15 New Inn Hall-street, Oxford.
1866. ‡Rolph, George Frederick. War Office, Horse Guards, London, S.W.
1863. ‡Romilly, Edward. 14 Hyde Park-terrace, London, W.
1845. ‡*Romily, Rev. Joseph.*
1845. ‡Ronalds, Francis, F.R.S. 9 St. Mary's-villas, Battle, Essex.
1846. ‡Ronalds, Edmund, Ph.D. Stewartfield, Bonnington, Edinburgh.
1865. ‡Roper, R. S. Newport, Monmouthshire.
1861. *Roscoe, Henry Enfield, B.A., Ph.D., F.R.S., F.C.S., Professor of Chemistry in Owens College, Manchester.
1861. §Rose, C. B., F.G.S. 25 King-street, Great Yarmouth, Norfolk.
1863. ‡Roseby, John. Haverholme House, Brigg, Lincolnshire.
1857. ‡Ross, David, LL.D. Drumbrain Cottage, Newbliss, Ireland.
1859. *Ross, James Coulman. Trinity College, Cambridge.
1861. *Ross, Thomas. Featherstone-buildings, High Holborn, London, W.C.
1842. Ross, William. Pendleton, Manchester.
Rosson, John. Moore Hall, near Ormskirk, Lancashire.
1855. ‡Roth, Dr. Matthias. 16A Old Cavendish-street, London, W.
1865. *Rothera, George Bell. 39 Upper Talbot-street, Nottingham.
1846. ‡Roundall, William B. 146 High-street, Southampton.
*Roundell, Rev. Danson Richardson. Gledstone, Skipton.
1849. §Round, Daniel G. Hange Colliery, near Tipton, Staffordshire.
1847. ‡Rouse, William. 16 Canterbury Villas, Maida Vale, London, W.
1861. ‡Routh, Edward J., M.A. St. Peter's College, Cambridge.
1861. ‡Rowan, David. St. Vincent Crescent, Glasgow.
1855. ‡Rowand, Alexander. Linthouse, near Glasgow.
1865. §Rowe, Rev. John. Beaufort-villas, Edgbaston, Birmingham.
1855. *Rowney, Thomas H., Ph.D., F.C.S., Professor of Chemistry in Queen's College, Galway.
*Rowntree, Joseph. Leeds.
1862. ‡Rowsell, Rev. Evan Edward, M.A. Hambledon Rectory, Godalming.
1861. *Royle, Peter, M.D., L.R.C.P., M.R.C.S. 27 Lever-street, Manchester.
1859. ‡*Ruland, C. H.*
1861. *Rumney, Robert, F.C.S. Ardwick, Manchester.

Year of Election.

1856. ‡Rumsay, Henry Wildbore. Gloucester Lodge, Cheltenham.
1847. ‡Ruskin, John, M.A., F.G.S. Denmark-hill, Camberwell, London, S.
1857. ‡Russell, Rev. C. W., D.D. Maynooth College.
1855. ‡Russell, James, jun. Falkirk.
1865. ‡Russell, James, M.D. 91 Newhall-street, Birmingham.
1859. ‡Russell, John, the Right Hon. Earl, K.G., F.R.S., F.R.G.S. 37 Chesham-place, Belgrave-square, London, S.W.
Russell, John. 15 Middle Gardiner's-street, Dublin.
Russell, John Scott, M.A., F.R.S. L. & E. Sydenham; and 5 Westminster Chambers, London, S.W.
1852. *Russell, Norman Scott. 37 Great George-street, London, S.W.
1853. ‡*Russell, Robert.*
1863. ‡Russell, Robert. Gosforth Colliery, Newcastle-on-Tyne.
Russell, Rev. T.
1852. *Russell, William J., Ph.D. 34 Upper Hamilton-terrace, St. John's Wood, London.
1862. §Russell, W. H. L., A.B., F.R.S. Shepperton, Middlesex.
1865. ‡Rust, Rev. James, M.A. Manse of Slains, Ellon, N. B.
Rutson, William. Newby Wiske, Northallerton, Yorkshire.
1852. ‡*Ryan, John, M.D.*
*Ryland, Arthur. Birmingham.
1865. ‡Ryland, Thomas. The Redlands, Erdington, Birmingham.
1853. ‡Rylands, Joseph. 9 Charlotte-street, Hull.
1861. *Rylands, Thomas Glazebrook. Heath House, Warrington.

*Sabine, Major-General Edward, R.A., LL.D., D.C.L., President of the Royal Society, F.R.A.S., F.L.S., F.R.G.S. 13 Ashley-place, Westminster, London.
1865. ‡Sabine, Robert. (Care of C. W. Siemens, Esq.), 3 Great George-street, London, S.W.
1866. *St. Albans, His Grace the Duke of. Brestwood Hall, near Nottingham.
Salkeld, Joseph. Penrith, Cumberland.
1857. ‡Salmon, Rev. George, D.D., F.R.S., Regius Professor of Divinity in the University of Dublin. Trinity College, Dublin.
1864. ‡*Salmon, Henry C., F.G.S., F.C.S.*
Salmon, William Wroughton. 9 Regent's Park-square, London, N.W.; and Devizes, Wiltshire.
1854. *Salt, Charles F. 24 Grove-street, Liverpool.
1858. *Salt, Titus. Crow Nest, Lightcliffe, Halifax.
1856. ‡Salter, John William, F.G.S. Geological Survey of Great Britain, Museum of Practical Geology, Jermyn-street; and 8 Bolton-road, Boundary-road, St. John's Wood, London, N.W.
1842. Sambrooke, T. G. 32 Eaton-place, London, S.W.
1861. *Samson, Henry. Messrs. Samson and Leppoe, St. Peter's-square, Manchester.
1867. §Samuelson, Edward. Roby, near Liverpool.
1854. ‡Sandbach, Henry R. Hafodunos, Denbighshire.
1861. *Sandeman, A., M.A. Tulloch, Perth.
1857. ‡Sanders, Gilbert. The Hill, Monkstown, Co. Dublin.
Sanders, John Naish, F.G.S. 12 Vyvyan-terrace, Clifton, Bristol.
*Sanders, William, F.R.S., F.G.S. (*Local Treasurer.*) 21 Richmond-terrace, Clifton, Bristol.
Sandes, Thomas, A.B. Sallow Glin, Tarbert, Co. Kerry.
1864. ‡Sandford, William. 9 Springfield-place, Bath.
1854. ‡Sandon, Lord. 39 Gloucester-square, London, W.
1864. ‡Sanford, William A. Nynehead Court, Wellington, Somersetshire.
1865. ‡Sargant, W. L. Edmund-street, Birmingham.
Satterfield, Joshua. Alderley Edge.

Year of Election.

1861. ‡Saul, Charles J. Smedley-lane, Cheetham-hill, Manchester.
1846. ‡*Saunders, Trelawney William.*
1864. ‡Saunders, T. W., Recorder of Bath. 1 Priory-place, Bath.
1860. *Saunders, William. Manor House, Iffley, near Oxford.
1863. ‡Savory, Valentine. Cleckheaton, near Leeds.
1857. ‡Scallan, James Joseph. 77 Harcourt-street, Dublin.
1850. ‡Scarth, Pillans. 28 Barnard-street, Leith.
***Schemman, J. C. Hamburg.*
***Schlick, Commandeur de.*
1842. *Schofield, Benjamin.*
1842. Schofield, Joseph. Stubley Hall, Littleborough, Lancashire.
1842. Schofield, W. F. Fairlawn, Ripon.
*Scholes, T. Seddon. 16 Dale-street, Leamington.
1847. *Scholey, William Stephenson, M.A. Freemantle Lodge, Castle-hill, Reading.
*Scholfield, Edward, M.D. Doncaster.
1854. ‡*Scholfield, Henry D., M.D.*
Schunck, Edward, F.R.S. Oaklands, Kersall Moor, Manchester.
1861. *Schwabe, Edmund Salis. Rhodes House, near Manchester.
1867. §Schwendler, Louis. 9 Armstrong-terrace, Charlton, London, S.E.
1847. ‡Sclater, Philip Lutley, M.A, Ph.D., F.R.S., F.L.S., Sec. Zool. Soc. 11 Hanover-square, London, W.
1849. ‡Scoffern, John, M.B. Barnard's Inn, London; and Ilford, Essex.
1867. §Scott, Alexander. Clydesdale Bank, Dundee.
1865. §Scott, Major-General, Royal Bengal Artillery. Treledan Hall, Montgomeryshire.
1859. ‡Scott, Captain Fitzmaurice. Forfar Artillery.
1855. ‡Scott, Montague D., B.A. Hove, Sussex.
1857. §Scott, Robert H., F.G.S., Director of the Meteorological Office, Parliament-street, London, S.W.
1861. §Scott, Rev. Robert Selkirk, M.A. 7 Beaufort-terrace, Cecil-street, Manchester.
1864. ‡Scott, Wentworth Lascelles, F.C.S. Cornwall-villa, 24 Cornwall-road, Westbourne Park, London, W.
1858. ‡Scott, William. Holbeck, near Leeds.
1864. ‡Scott, William Robson, Ph.D. St. Leonards, Exeter.
1856. ‡*Scougall, James.*
1854. ‡Scrivenor, Harry. Ramsay, Isle of Man.
1859. ‡Seaton, John Love. Hull.
*Sedgwick, Rev. Adam, M.A., LL.D., F.R.S., Hon. M.R.I.A., F.G.S., F.R.A.S., F.R.G.S., Woodwardian Professor of Geology in the University of Cambridge, and Canon of Norwich. Trinity College, Cambridge.
1853. ‡Sedgwick, Rev. James. Scalby Vicarage, Scarborough.
1861. *Seeley, Harry, F.G.S. Woodwardian Museum, Cambridge.
Selby, Prideaux John, F.L.S., F.G.S. Twizel House, Belford, Northumberland.
1855. ‡Seligman, H. L. 135 Buchanan-street, Glasgow.
1850. ‡Seller, William, M.D. 23 Nelson-street, Edinburgh.
*Selwyn, Rev. William, M.A., Prebendary of Ely. Foxton, Royston.
1858. *Senior, George, F.S.S. Regent-street, Barnsley.
Seymour, George Hicks. Stonegate, York.
1861. *Seymour, Henry D., M.P. 39 Upper Grosvenor-street, London, W.
Seymour, John. 21 Bootham, York.
1853. ‡Shackles, G. L. 6 Albion-street, Hull.
*Shaen, William. 8 Bedford-row, London, W.C.
1867. §Shanks, James. Den Iron Works, Arbroath, N. B.
1846. ‡Sharp, James. 22 Oxford-street, Southampton.

Year of Election.

Sharp, Rev. John, B.A. Horbury, Wakefield.
1861. §Sharp, Samuel, F.G.S., F.S.A. Dallington Hall, near Northampton.
*Sharp, William, M.D., F.R.S., F.G.S. Horton House, Rugby.
Sharp, Rev. William, B.A. Mareham Rectory, near Boston, Lincolnshire.
1854. ‡*Sharpe, Robert, M.D.*
Sharpey, William, M.D., LL.D., Sec. R.S., F.R.S.E., Professor of Anatomy and Physiology in University College. Lawnbank, Hampstead, London, N.W.
1858. *Shaw, Bentley. Woodfield House, Huddersfield.
1854. *Shaw, Charles Wright. 3 Windsor-terrace, Douglas, Isle of Man.
1858. ‡*Shaw, Edward W.*
1865. ‡Shaw, George. Cannon-street, Birmingham.
1845. ‡Shaw, John, M.D., F.L.S., F.G.S. Viatoris Villa, Boston, Lincolnshire.
1861. *Shaw, John. City-road, Hulme, Manchester.
1858. ‡Shaw, John Hope. Headingley, Leeds.
1853. ‡Shaw, Norton, M.D. St. Croix, West Indies.
Shepard, John. Nelson-square, Bradford, Yorkshire.
1863. ‡Shepherd, A. B. 7 South-square, Gray's Inn, London, W.C.
Sheppard, Rev. Henry W., B.A. The Parsonage, Emsworth, Hampshire.
*Sherrard, David Henry. 88 Upper Dorset-street, Dublin.
1851. ‡Shewell, John T. Rushmere, Ipswich.
1866. ‡Shilton, Samuel Richard Parr. Sneinton House, Nottingham.
1849. ‡*Shorthouse, Joseph.*
1846. *Shortrede, Colonel Robert, F.R.A.S. The Bowans, Lee-road, Blackheath, London, S.E.
1864. ‡Showers, Lieut.-Colonel Charles L. Cox's Hotel, Jermyn-street, London, S.W.
1842. Shuttleworth, John. Wilton Polygon, Cheetham-hill, Manchester.
1866. ‡Sibson, Francis, M.D., F.R.S. 40 Brook-street, Grosvenor-square, London, W.
1861. *Sidebotham, Joseph. 19 George-street, Manchester.
1861. *Sidebottom, James. Portland-street, Manchester.
1861. *Sidebottom, James, jun. Spring-bank Mills, Stockport.
1857. ‡Sidney, Frederick John. 19 Herbert-street, Dublin.
Sidney, M. J. F. Cowpen, Newcastle-upon-Tyne.
1856. §Siemens, C. William, F.R.S. 3 Great George-street, London, S.W.
Sigmond, George, M.D., F.S.A.
*Sillar, Zechariah, M.D. Bath House, Laurie Park, Sydenham, London, S.E.
1859. ‡Sim, John. Hardgate, Aberdeen.
1855. ‡Sim, William. Furnace, near Inverary.
1851. ‡*Sim, W. D. Ipswich.*
1865. §Simkiss, T. M. 38 Waterloo-road South, Wolverhampton.
1862. ‡Simms, James. 138 Fleet-street, London, E.C.
1852. ‡Simms, William. Albion-place, Belfast.
1847. ‡Simon, John. King's College, London, W.C.
1866. ‡Simons, George. The Park, Nottingham.
1850. ‡Simpson, Professor Sir James Y. Edinburgh.
1867. §Simpson, G. B. Seafield, Broughty Ferry, by Dundee.
1859. ‡Simpson, John. Marykirk, Kincardineshire.
1863. §Simpson, J. B., F.G.S. Hedgefield House, Blaydon-on-Tyne.
1857. ‡Simpson, Maxwell, M.D., F.R.S. 33 Wellington-road, Dublin.
*Simpson, Rev. Samuel. Douglas, Isle of Man.
Simpson, Thomas. Blake-street, York.

Year of Election.

Simpson, William. Bradmore House, Hammersmith, London, W.
1859. ‡Sinclair, Alexander. 133 George-street, Edinburgh.
1850. ‡Sinclair, Rev. William. Leeds.
1864. *Sircar, Baboo Mohendro Lall, M.D. 1344 San Kany, Tollah-street, Calcutta, per Messrs. Harrenden & Co., 3 Chaple-place, Poultry, London, E.C.
*Sirr, Rev. Joseph D'Arcy, D.D., M.R.I.A. Castle-hill, Winchester.
1865. §Sissons, W. Saw Mills, Hull.
1850. ‡Skae, David, M.D. Royal Asylum, Edinburgh.
1850. ‡*Skane, William Forbes.*
1859. ‡*Skinner, James.*
1842. *Slater, William. Princess-street, Manchester.
1853. §Sleddon, Francis. 2 Kingston-terrace, Hull.
1849. §Sloper, George Edgar, jun. Devizes.
1849. ‡Sloper, Samuel W. Devizes.
1860. §Sloper, S. Elgar. Winterton, near Southampton.
1867. §Small, David. Gray House, Dundee.
1867. §Small, William. Dundee.
1858. ‡Smeeton, G. H. Commercial-street, Leeds.
1867. §Smeiton, John G. Panmure Villa, Broughty Ferry, Dundee.
1867. §Smeiton, Thomas A. 55 Cowgate, Dundee.
1857. ‡Smith, Aquila, M.D., M.R.I.A. 121 Lower Bagot-street, Dublin.
Smith, Archibald, M.A., F.R.S. L. & E. River-bank, Putney; and 3 Stone-buildings, Lincoln's Inn, London, W.C.
1860. §Smith, Brooke. 51 Frederick-street, Edgbaston, Birmingham.
Smith, Rev. B., F.S.A.
1861. *Smith, Charles Edward, F.R.A.S. Fir Vale, near Sheffield.
1865. §Smith, David, F.R.A.S. 4 Cherry-street, Birmingham.
1853. ‡Smith, Edmund. Ferriby, near Hull.
1859. ‡Smith, Edward, M.D., LL.B., F.R.S. 16 Queen Anne-street, London, W.
1865. ‡Smith, Frederick. The Priory, Dudley.
1866. *Smith, F. C. Bramcote, Nottingham.
1855. ‡Smith, George. Port Dundas, Glasgow.
1855. ‡Smith, George Cruickshank. 19 St. Vincent-place, Glasgow.
*Smith, Rev. George Sidney, D.D., M.R.I.A., Professor of Biblical Greek in the University of Dublin. Aughalurcher, Five-mile-Town, Co. Tyrone.
1859. ‡Smith, G. Campbell. Banff.
1859. ‡Smith, Henry A. 5 East Craibstone-street, Aberdeen.
*Smith, Henry John Stephen, M.A., F.R.S., Savilian Professor of Geometry in the University of Oxford. 64 St. Giles's, Oxford.
1860. *Smith, Heywood., M.A., M.B. 25 Park-street, Grosvenor-square, London, W.
1865. §Smith, Isaac. 26 Lancaster-street, Birmingham.
1842. *Smith, James. Berkeley House, Seaforth, near Liverpool.
1859. ‡*Smith, James.*
1855. ‡Smith, James. St. Vincent-street, Glasgow.
1867. §Smith, James P., C.E. Glasgow.
*Smith, John. Shelbrook House, Ashby-de-la-Zouch.
1850. ‡*Smith, John, M.D. Edinburgh.*
1853. ‡Smith, John. York City and County Bank, Malton, Yorkshire.
1858. *Smith, John Metcalf. (*Local Treasurer.*) Bank, Leeds.
Smith, John Peter George. Liverpool.
1864. §Smith, John S. Sydney Lodge, Wimbledon, Surrey.
1852. *Smith, Rev. Joseph Denham. Kingstown, near Dublin.
1861. ‡Smith, Professor J., M.D. University of Sydney, Australia.
1845. ‡Smith, Rev. J. J. Caius College, Cambridge.

Year of Election.

*Smith, Philip, B.A. 7 Cantelowes-road, Camden-square, London, N.W.
1860. *Smith, Protheroe, M.D. 25 Park-street, Grosvenor-square, London, W.
1837. Smith, Richard Bryan. Villa Nova, Shrewsbury.
1847. ‡Smith, Robert Angus, Ph.D., F.R.S., F.C.S. 20 Devonshire-street, Manchester.
*Smith, Robert Mackay. Bellevue-crescent, Edinburgh.
1866. §Smith, Samuel. 33 Compton-street, Goswell-road, London, E.C.
1867. §Smith, Sheriff. Dundee.
1867. §Smith, Thomas. Dundee.
1859. ‡Smith, Thomas James, F.G.S., F.C.S. Hessle, near Hull.
1852. ‡Smith, William. Eglinton Engine Works, Glasgow.
1857. §Smith, William, C.E., F.G.S. 19 Salisbury-street, Adelphi, London, W.C.
1850. *Smyth, Charles Piazzi, F.R.S. L. & E., F.R.A.S., Astronomer Royal for Scotland, Professor of Practical Astronomy in the University of Edinburgh. 1 Hillside-crescent, Edinburgh.
1857. *Smyth, John, jun., M.A., C.E. Milltown, Banbridge, Ireland.
1864. ‡Smyth, Warington W., M.A., F.R.S., F.G.S., Lecturer on Mining at the Government School of Mines, and Inspector of the Mineral Property of the Crown. 27 Victoria-street, London, S.W.
1854. ‡Smythe, Colonel W. J., R.A. Woolwich.
Soden, John. Athenæum Club, Pall Mall, London, S.W.
1853. ‡Sollitt, J. D., Head Master of the Grammar School, Hull.
*Solly, Edward, F.R.S., F.S.A. Sandecotes, near Poole.
*Sopwith, Thomas, M.A., F.R.S., F.G.S., F.R.G.S. 103 Victoria-street, Westminster, London, S.W.
Sorbey, Alfred. The Rookery, Ashford, Bakewell.
1859. *Sorby, H. Clifton, F.R.S., F.G.S. Broomfield, Sheffield.
1861. ‡Sorensen, Le Chevalier B. Norway.
1865. *Southall, John Tertius. Leominster.
1859. ‡Southall, Norman. 44 Cannon-street West, London, E.C.
1856. ‡Southwood, Rev. T. A. Cheltenham College.
1863. ‡Sowerby, John. Shipcote House, Gateshead, Durham.
1863. *Spark, H. King. Greenbank, Darlington.
1859. ‡Spence, Rev. James, D.D. 6 Clapton-square, London, N.E.
*Spence, Joseph. Pavement, York.
1854. §Spence, Peter. Pendleton Alum Works, Newton Heath; and Smedley Hall, near Manchester.
1845. ‡*Spence, W. B.*
1861. §Spencer, John Frederick. St. Nicholas-buildings, Newcastle-on-Tyne.
1861. *Spencer, Joseph. 27 Brown-street, Manchester.
1863. **Spencer, Thomas.*
1855. ‡Spens, William. 78 St. Vincent-street, Glasgow.
1864. *Spicer, Henry, jun. 22 Highbury-crescent; and 19 New Bridge-street, Blackfriars, London, E.C.
Spicer, Thomas Trevetham, M.A., LL.D.
1864. §Spicer, William R. 19 New Bridge-street, Blackfriars, London, E.C.
1847. *Spiers, Richard James, F.S.A. 14 St. Giles's-street, Oxford.
1864. *Spiller, Captain John, F.C.S. Chemical Department, Royal Arsenal, Woolwich.
1846. *Spottiswoode, William, M.A., V.P.R.S., F.R.A.S., F.R.G.S. (*General Treasurer.*) 50 Grosvenor-place, London, S.W.
1864. *Spottiswoode, W. Hugh. 50 Grosvenor-place, London, S.W.
1854. *Sprague, Thomas Bond. 18 Lincoln's Inn Fields, London, W.C.
1853. ‡Spratt, Joseph James. West Parade, Hull.
Square, Joseph Elliot. Plymouth.

Year of Election.

*Squire, Lovell. Falmouth.
1859. ‡Stables, William Alexander. Cawdor Castle, Nairn, N.B.
1857. ‡*Stack, Thomas. Dublin.*
1858. *Stainton, Henry T., F.R.S., F.L.S., F.G.S. Mountsfield, Lewisham, Kent.
1851. *Stainton, James Joseph, F.L.S., F.C.S. Horsell, near Ripley, Surrey.
Stamforth, Rev. Thomas.
Stanfeld, Hamer. Burley, near Otley.
1858. ‡Stanfield, Alfred W. Wakefield.
1865. §Stanford, Edward C. C. 1 Holyrood-crescent, Glasgow.
1856. *Stanley, The Right Hon. Lord, M.P., LL.D., F.R.S., F.R.G.S. 23 St. James's-square, London; and Knowsley, Liverpool.
Stanley, The Very Rev. Arthur Penrhyn, D.D., F.R.S., Dean of Westminster. The Deanery, Westminster, London, S.W.
Stapleton, H. M. 1 Mountjoy-place, Dublin.
1866. §Starey, Thomas R. Daybrook House, Nottingham.
1850. ‡Stark, James, M.D., F.R.S.E. 21 Rutland-street, Edinburgh.
1863. ‡Stark, Richard M. Hull.
1848. ‡Statham, Henry Joseph. 27 Mortimer-street, Cavendish-square, London, W.
Staveley, T. K. Ripon, Yorkshire.
1857. ‡Steel, William Edward, M.D. 15 Hatch-street, Dublin.
1863. §Steele, Rev. Dr. 2 Bathwick-terrace, Bath.
1861. ‡Steinthal, H. M. Hollywood, Fallowfield, near Manchester.
Stenhouse, John, Ph.D. 17 Rodney-street, Pentonville, London, N.
1863. §Sterriker, John. Driffield.
1861. *Stern, S. J. 33 George-street, Manchester.
1861. *Stevens, Henry, F.S.A., F.R.G.S. 4 Trafalgar-square, London, W.C.
1863. ‡Stevenson, Archibald. South Shields.
1850. ‡Stevenson, David. 8 Forth-street, Edinburgh.
Stevenson, Rev. Edward, M.A.
1863. *Stevenson, James C. South Shields.
1855. Stewart, Balfour, M.A., LL.D., F.R.S., Superintendent of the Kew Observatory of the British Association. Richmond, Surrey.
1864. ‡Stewart, Charles, F.L.S. 19 Princess Square, Plymouth.
1856. *Stewart, Henry Hutchinson, M.D., M.R.I.A. 71 Eccles-street, Dublin.
1859. ‡*Stewart, John. Glasgow.*
Stewart, Robert. Glasgow.
1847. ‡Stewart, Robert, M.D. The Asylum, Belfast.
*Stirling, Andrew. Lower Mosley-street, Manchester.
1867. §Stirling, Dr. D. Perth.
1867. *Stirrup, Mark. 1 St. Andrew's-terrace, Cornbrook, Manchester.
1865. *Stock, Joseph S. Cannon-street, Birmingham.
1849. ‡Stock, T. S. Bourn Brook Hall.
1862. ‡Stockil, William. 5 Church Meadows, Sydenham, London, S.E.
Stoddart, George. 11 Russell-square, London, W.C.
1864. §Stoddart, William Walter, F.G.S. 9 North-street, Bristol.
1854. ‡Stoep, Charles (Consul). 6 Cook-street, Liverpool.
*Stokes, George Gabriel, M.A., D.C.L., Sec. R.S., Lucasian Professor of Mathematics in the University of Cambridge. Pembroke College, Cambridge.
1845. ‡Stokes, Rev. William H., M.A., F.G.S. Cambridge.
1862. ‡Stone, E. J., M.A. Royal Observatory, Greenwich, London.
1859. ‡Stone, Dr. William H. 13 Vigo-street, London, W.
1857. ‡Stoney, Bindon B., M.R.I.A. 89 Waterloo-road, Dublin.

Year of Election.

1861. *Stoney, George Johnstone, M.A., M.D., F.R.S., M.R.I.A., Secretary to the Queen's University, Ireland. Dublin Castle, Dublin.
1854. ‡Store, George. Prospect House, Fairfield, Liverpool.
1859. §Story, James. 17 Bryanston-square, London, W.
1867. §Storrar, John. Hampstead, London, N.W.
Stowe, William. Buckingham.
Stowell, Rev. H. Acton-square, Salford, Manchester.
Strachan, James M. The Grove, Teddington, Middlesex.
1859. ‡*Strachan, Patrick.*
1863. ‡Strachan, T. Y. Lovaine-crescent, Newcastle-on-Tyne.
1863. ‡Straker, John. Wellington House, Durham.
1850. ‡*Strange, John, LL.B. Edinburgh.*
*Strickland, Arthur. Bridlington Quay, Yorkshire.
*Strickland, Charles. Loughglyn, Ballaghadereen, Ireland.
1845. ‡*Strickland, Henry Eustatius.*
Strickland, J. E. French-park, Roscommon, Ireland.
Strickland, William. French-park, Roscommon, Ireland.
1859. ‡Stronach, William, R.E. Ardmellie, Banff.
1867. §Stronner, D. 20 Princess-street, Dundee.
1866. *Strutt, The Hon. Arthur. Kingston Hall, near Derby.
1848. ‡Struvé, William Price. Picton-place, Swansea.
Stroud, Rev. Joseph, M.A.
Stuart, Robert.
1854. ‡Stuart, William. 1 Rumford-place, Liverpool.
1861. ‡*Stuart, W. D. Philadelphia.*
1859. ‡*Stuart, William Henry.*
1866. ‡Stubbins, Henry. Lincoln's-Inn, London, W.C.
1864. ‡Style, Sir Charles, Bart. 102 New Sydney-place, Bath.
1857. ‡Sullivan, William K., Ph.D., M.R.I.A. Museum of Irish Industry; and 53 Upper Leeson-road, Dublin.
1863. ‡Sutherland, Benjamin John. 10 Oxford-street, Newcastle-on-Tyne.
1862. *Sutherland, George Granville William, Duke of, K.G., F.R.G.S. Stafford House, London, S.W.
1855. ‡Sutton, Edwin. 44 Winchester-street, Pimlico, London, S.W.
1863. §Sutton, Francis, F.C.S. Bank Plain, Norwich.
1861. *Swan, Patrick Don S. Kirkaldy, N.B.
1862. *Swan, William, Professor of Natural Philosophy in the University of St. Andrews, N. B.
1863. ‡Swan, William. Walker, Durham.
1862. *Swann, Rev. S. K. Gedling, near Nottingham.
Swanwick, J. W.
Sweetman, Walter, M.A., M.R.I.A. 4 Mountjoy-square North, Dublin.
1863. §Swindell, J. S. E. Summerhill, Kingswinford, Dudley.
1863. ‡Swinhoe, Robert, F.R.G.S. Oriental Club, London, W.
1859. ‡Sykes, Alfred. Leeds.
1847. ‡Sykes, H. P. 47 Albion-street, Hyde Park, London, W.
1862. ‡Sykes, Thomas. Cleckheaton, near Leeds.
*Sykes, Colonel William Henry, M.P., F.R.S., Hon. M.R.I.A., F.G.S., F.R.G.S. 47 Albion-street, Hyde Park, London, W.
1847. ‡Sykes, Captain W. H. F. 47 Albion-street, Hyde Park, London.
Sylvester, James Joseph, M.A., LL.D., F.R.S., Professor of Mathematics in the Royal Military Academy, Woolwich. Woolwich; and Athenæum Club, London, S.W.
1850. ‡Syme, James, Professor of Clinical Surgery in the University of Edinburgh. The College, Edinburgh.
1856. *Symonds, Frederick, F.R.C.S. Beaumont-street, Oxford.
1859. ‡Symonds, Captain Thomas Edward, R.N. 10 Adam-street, Adelphi, London, W.C.

Year of Election.

1860. ‡Symonds, Rev. W. S., M.A., F.G.S. Pendock Rectory, Worcestershire.
1859. §Symons, G. J., F.M.S. 136 Camden-road, London, W.N.
1855. *Symons, William, F.C.S. 26 Joy-street, Barnstaple.
Synge, Rev. Alexander. St. Peter's, Ipswich.
Synge, Francis. Glanmore, Ashford, Co. Wicklow.
Synge, John Hatch. Glanmore, Ashford, Co. Wicklow.

1865. ‡Tailyour, Colonel Renny, R.E. Newmanswalls, Montrose, N. B.
1867. §Tait, P. M., F.R.G.S. 26 Adelaide Road, N.; and Oriental Club, Pall Mall, London, S.W.
§Talbot, William Hawkshead. Southport, Lancashire.
Talbot, William Henry Fox, M.A., LL.D., F.R.S., F.L.S. Lacock Abbey, near Chippenham.
1867. *Tanner, Thomas Hawkes, M.D., F.L.S. 9 Henrietta-street, Cavendish-square, London, W.
1866. ‡Tarbottom, Marrott Ogle, M.I.C.E. Newstead-grove, Nottingham.
Taprell, William. 7 Westbourne-crescent, Hyde Park, London, W
1861. *Tarratt, Henry W. Bushbury Lodge, Leamington.
1856. ‡Tartt, William Macdonald, F.S.S. Sandford-place, Cheltenham.
1864. ‡Tasker, Rev. J. C. W. 1 Upper Lansdown-villas, Bath.
1857. *Tate, Alexander. 20 Queen-street, Belfast.
1863. ‡Tate, John. Alnmouth, near Alnwick, Northumberland.
1865. ‡Tate, Thomas. Ore, Hastings.
1858. *Tatham, George. Leeds.
1864. *Tawney, Edward. 5 Victoria-square, Clifton, Bristol.
*Tayler, Rev. John James, B.A., Principal and Professor of Ecclesiastical History in Manchester New College, London. 22 Woburn-square, London, W.C.
1867. §Taylor, Rev. Andrew. Dundee.
Taylor, Frederick. Messrs. Taylor, Potter & Co., Liverpool.
1854. ‡Taylor, Dr. H. R. 1 Percy-street, Liverpool.
*Taylor, James. Culverlands, near Reading.
*Taylor, John, F.G.S. 6 Queen-street-place, Upper Thames-street, London, E.C.
1861. *Taylor, John, jun. 6 Queen-street-place, Upper Thames-street, London, E.C.
1856. ‡*Taylor, John.*
1863. ‡Taylor, John. Earsdon, Newcastle-on-Tyne.
1863. ‡Taylor, John. Lovaine-place, Newcastle-on-Tyne.
1865. ‡Taylor, Joseph. 99 Constitution-hill, Birmingham.
**Taylor, Vice-Admiral J. N., C.B.*
Taylor, Captain P. Meadows, in the Service of His Highness the Nizam. Harold Cross, Dublin.
*Taylor, Richard, F.G.S. 6 Queen-street-place, Upper Thames-street, London, E.C.
Taylor, Rev. William, F.R.S., F.R.A.S. Thornloe, Worcester.
*Taylor, William Edward. Millfield House, Enfield, near Accrington.
1858. ‡Teale, Joseph. Leeds.
1858. ‡Teale, Thomas Pridgin, jun. 20 Park-row, Leeds.
Teather, John. Alstonley, Cumberland.
1865. *Templeton, James. Mansion-house School, St. David's, Exeter.
Tennant, Charles. Glasgow.
1863. ‡Tennant, Henry. Saltwell, Newcastle-on-Tyne.
*Tennant, James, F.G.S., F.R.G.S., Professor of Mineralogy and Geology in King's College, London. 149 Strand, London, W.C.
Tennent, R. J. Belfast.
1857. ‡Tennison, Edward King. Kildare-street Club House, Dublin.
1849. ‡Teschemacher, E. F. Highbury-park North, London, N.

Year of Election.

1866. ‡Thackeray, J. L. Arno Vale, Nottingham.
1859. ‡Thain, Rev. Alexander. New Machar, Aberdeen.
1848. ‡Thirlwall, The Right Rev. Connop, D.D. Abergwili, Carmarthen.
1856. ‡Thodey, Rev. S. Rodborough, Gloucestershire.
Thom, Rev. David, D.D., Ph.D.
Thom, John. Messrs. M^{c}Naughton & Co., Moseley-street, Manchester.
Thomas, George. Brislington, Bristol.
1848. **Thomas, George John, M.A.*
1854. ‡*Thompson, Benjamin James.*
1854. ‡*Thompson, D. P., M.D.*
1854. ‡Thompson, Edmund. Claughton Park, Birkenhead.
1863. ‡Thompson, Rev. Francis. St. Giles's, Durham.
1858. *Thompson, Frederick. South Parade, Wakefield.
1859. §Thompson, George, jun. Pidsmedden, Aberdeen.
Thompson, Harry Stephen. Kirby Hall, Great Ouseburn, Yorkshire.
Thompson, Henry Stafford. Fairfield, near York.
1845. ‡Thompson, James. Kirk Houses, Brampton, Cumberland.
1861. *Thompson, Joseph. Woodlands, Wilmslow, near Manchester.
1864. §Thompson, Rev. Joseph Hesselgrave, B.A. Cradley, near Brierley-hill.
Thompson, Leonard. Sheriff-Hutton Park, Yorkshire.
1853. ‡Thompson, Thomas (Austrian Consul). Hull.
Thompson, Thomas (Town Clerk). Hull.
1863. ‡Thompson, William. 11 North-terrace, Newcastle-on-Tyne.
1867. §Thoms, William. Magdalen Yard-road, Dundee.
1850. ‡Thomson, Alexander. Banchory House, by Aberdeen.
1855. ‡Thomson, Allen, M.D., Professor of Anatomy in the University, Glasgow.
*Thomson, Corden, M.D. Sheffield.
1867. §Thomson, Francis Hay, M.D. Glasgow.
1852. ‡Thomson, Gordon A. Bedeque House, Belfast.
Thomson, Guy. Oxford.
1850. ‡Thomson, James. Kendal.
1845. ‡*Thomson, Prof. James, LL.D.*
1855. ‡Thomson, James. 82 West Nile-street, Glasgow.
1850. *Thomson, Professor James, M.A., C.E. 2 Donegal-square West, Belfast.
*Thomson, James Gibson. Edinburgh.
1863. ‡Thomson, M. 8 Meadow-place, Edinburgh.
1865. §Thomson, R. W., C.E., F.R.S.E. 3 Moray-place, Edinburgh.
1850. ‡Thomson, Thomas, M.D., F.R.S. Hope House, Kew.
1847. *Thomson, Sir William, M.A., LL.D., D.C.L., F.R.S. L. & E., Professor of Natural Philosophy in the University of Glasgow. (*Local Treasurer.*) The College, Glasgow.
1850. ‡*Thomson, William Hamilton.*
1850. ‡Thomson, Wyville T. C., LL.D., F.G.S., Professor of Geology in Queen's College, Belfast.
1854. ‡*Thorburn, William, M.D.*
1852. ‡Thorburn, Rev. William Reid, M.A. Starkies, Bury, Lancashire.
1866. §Thornton, James. Edwalton, Nottingham.
*Thornton, Samuel. The Elms, Camp-hill, Birmingham.
1865. *Thornley, S. Sparkbrook, Birmingham.
1867. §Thornton, Thomas. Dundee.
1845. ‡Thorp, Dr. Disney. Suffolk Laun, Cheltenham.
*Thorp, The Venerable Thomas, B.D., F.G.S., Archdeacon of Bristol. Kemerton, near Tewkesbury.
1864. §Thorp, William, jun., F.C.S. 401 Kingsland-road, London, N.E.
Thurnam, John, M.D. Devizes.

Year of Election.

1856. ‡Tibbs, Somerset. 58 Regent-street, Cheltenham.
1865. §Timmins, Samuel. Elvetham-road, Edgbaston, Birmingham.
Tinker, Ebenezer. Mealhill, near Huddersfield.
*Tinné, John A., F.R.G.S. Briarly, Aigburth, Liverpool.
Tite, William, M.P., F.R.S., F.G.S., F.S.A. 42 Lowndes-square, London, S.W.
Tobin, Rev. John. Liscard, Cheshire.
1850. ‡Tod, James, Sec. Soc. of Arts. Edinburgh.
Todd, Rev. James Henthorn, D.D., M.R.I.A. Trinity College, Dublin.
1859. ‡Todd, Thomas. Mary Culter House, Aberdeen.
1861. *Todhunter, Isaac, M.A., F.R.S. Principal Mathematical Lecturer of St. John's College, Cambridge. Bourne House, Cambridge.
Todhunter, J. 3 College Green, Dublin.
1857. ‡Tombe, Rev. H. J. Ballyfree, Ashford, Co. Wicklow.
1856. ‡Tomes, Robert Fisher. Welford, Stratford-on-Avon.
1866. §Tomlin, J. R. Stoke Field, Newark.
1864. *Tomlinson, Charles, F.R.S., F.C.S. King's College, London, W.C.; and Highgate, London, N.
1863. ‡Tone, John F. Jesmond Villas, Newcastle-on-Tyne.
1865. §Tonks, Edmund B. C. L. Packwood Grange, Knowle, Warwickshire.
1865. §Tonks, William. 4 Carpenter-road, Edgbaston, Birmingham.
1865. §Tonks, William Henry. 4 Carpenter-road, Edgbaston, Birmingham.
1861. *Topham, John, A.I.C.E. 49 Shrubland Grove East, Dalston, London, N.E.
1863. ‡Torr, F. S. 38 Bedford-row, London, W.C.
1863. ‡Torrens, R. R. 2 Gloucester-place, Hyde Park, London, W.
Torrie, Thomas Jameson. Edinburgh.
1859. ‡Torry, Very Rev. John, Dean of St. Andrews. Coupar Angus, N.B.
Towgood, Edward. St. Neots, Huntingdonshire.
Townend, John.
Townend, Thomas.
Townend, T. S.
1860. ‡Townsend, John. 11 Burlington-street, Bath.
1857. ‡Townsend, Rev. Richard, M.A., F.R.S. Trinity College, Dublin.
1861. ‡Townsend, William. Attleborough Hall, near Nuneaton.
1854. ‡Towson, John Thomas. 47 Upper Parliament-street, Liverpool; and Local Marine Board, Liverpool.
1859. ‡Trail, Rev. Robert, M.A. Boyndie, Banff.
1859. ‡Trail, Samuel, LL.D., D.D. The Manse, Hanay, Orkney.
1850. ‡Traill, Professor, M.D. The University, Edinburgh.
Travers, Robert, M.B.
1865. ‡Travers, William, F.R.C.S. 1 Bath-place, Kensington, London, W.
1851. ‡Travis, W. H. Whitton, near Ipswich.
1859. ‡Trefusis, The Hon. C. Heaton, Devonshire.
Tregelles, Nathaniel. Neath Abbey, Glamorganshire.
Trench, F. A. Newlands House, Clondalkin, Ireland.
*Trevelyan, Arthur. Wallington, Newcastle-on-Tyne.
Trevelyan, Sir Walter Calverley, Bart., M.A., F.R.S.E., F.G.S., F.S.A., F.R.G.S. Athenæum Club, London, S.W.; Wallington, Northberland; and Nettlecombe, Somerset.
1860. §Tristram, Rev. H. B., M.A., F.L.S. Greatham Hospital, near Stockton-on-Tees.
1864. ‡Truell, Robert. Ballyhenry, Ashford, Co. Wicklow.
Tuckett, Francis. Frenchay, near Bristol.
1847. *Tuckett, Francis Fox. Frenchay, near Bristol.
Tuckett, Frederick. 4 Mortimer-street, Cavendish-square, London, W.
Tuckett, Henry. Frenchay, near Bristol.

Year of Election.

Tuke, J. H. Bank, Hitchen.
1867. §Tulloch, The Very Rev. Principal. St. Andrews, Fifeshire.
1865. §Turberville, H. Pilton, Barnstaple.
1854. ‡Turnbull, James, M.D. 86 Rodney-street, Liverpool.
1855. §Turnbull, John. 37 West George-street, Glasgow.
1856. ‡Turnbull, Rev. J. C. 8 Bays-hill Villas, Cheltenham.
*Turnbull, Rev. Thomas Smith, M.A., F.R.S., F.R.G.S. Blofield, Norfolk.
1861. *Turner, James Aspinal. Pendlebury, near Manchester.
Turner, Thomas, M.D. 31 Curzon-street, May Fair, London, W.
1863. §Turner, William, M.B., F.R.S.E., Professor of Anatomy in the University of Edinbugh. The University, Edinburgh.
1842. Twamley, Charles, F.G.S. 6 Queen's-road, Gloucester Gate, Regent's Park, London, N.W.
1859. ‡Twining, H. R. Grove Lodge, Clapham, London, S.
1847. ‡Twining, Richard. 13 Bedford-place, Russell-square, London, W.C.
1847. ‡Twiss, Sir Travers, D.C.L., F.R.S., F.R.G.S., Regius Professor of Civil Law in the University of Oxford, and Chancellor of the Diocese of London. 19 Park-lane, London, W.
1846. ‡Tylor, Alfred, F.G.S., F.L.S. Warwick-lane, London, E.C.
1865. §Tylor, Edward Burnett. Lindon, Wellington, Somerset.
1858. *Tyndall, John, LL.D., Ph.D., F.R.S., F.G.S., Professor of Natural Philosophy in the Royal Institution and Royal School of Mines. Royal Institution, Albemarle-street, London, W.
Tyrrell, John. Exeter.
1861. *Tysoe, John. Sedgley-road, Pendleton, near Manchester.

Upton, Rev. James Samuel, M.A., F.G.S.
1855. ‡Ure, John. 114 Montrose-street, Glasgow.
1859. ‡Urquhart, Rev. Alexander. Tarbat, Ross-shire.
1859. ‡Urquhart, W. Pollard. Craigston Castle, N.B.; and Castlepollard, Ireland.
1866. §Urquhart, William W. Nursery House, Dundee.

*Vallack, Rev. Benjamin W. S. St. Budeaux, near Plymouth.
1854. ‡Vale, James Theodorick. Hamilton-square, Birkenhead.
*Vance, Rev. Robert. 16 Montpellier-hill, Dublin.
1863. ‡Vandoni, le Commandeur Comte de, Chargé d'Affaires de S. M. Tunisienne, Geneva.
1853. §Varley, Cornelius. 337 Kentish Town-road, London, N.W.
1854. ‡*Varley, Cromwell F.*
1865. *Varley, S. Alfred. 66 Roman-road, Holloway, London, N.
1863. ‡Vauvert, de Mean A., Vice-Consul for France. Tynemouth.
1849. *Vaux, Frederick. Central Telegraph Office, Adelaide, South Australia.
Vavasour, Sir Henry Mervun, Bart.
Veitch, A. J., M.D.
Verney, Sir Harry, Bart. Lower Claydon, Buckinghamshire.
1866. §Vernon, Rev. E. H. Harcourt. Cotgrave Rectory, near Nottingham.
Vernon, George John, Lord. 32 Curzon-street, London, W.; and Sudbury Hall, Derbyshire.
1854. *Vernon, George V., F.R.A.S. Piccadilly Mills; and Old Trafford, Manchester.
1854. *Vernon, John. High Lee, Woolton, Liverpool.
Veysie, Rev. Daniel, B.D. Daventry.
1864. *Vicary, William, F.G.S. The Priory, Colleston, Exeter.
1859. ‡*Vickers, Thomas.*
1854. *Vignoles, Charles, C.E., F.R.S., M.R.I.A., F.R.A.S. 21 Duke-street, Westminster, London, S.W.

Year of Election.

1856. ‡Vivian, Edward, B.A. Woodfield, Torquay.
*Vivian, H. Hussey, M.P., F.G.S. 5 Upper Belgrave-street, London, S.W.; and Singleton House, Swansea.
1856. §Voelcker, J. Ch. Augustus, Ph.D., F.C.S. 39 Argyll-road, Kensington, London, W.
Voelker, Professor Charles. Switzerland.
Vye, Nathaniel. Ilfracombe, Devon.

1860. §Waddingham, John. Guiting Grange, Winchcombe, Gloucestershire.
1859. ‡Waddington, John. New Dock Works, Leeds.
1855. *Waldegrave, The Hon. Granville. 26 Portland-place, London, W.
1863. ‡*Walker, Alfred O.*
1849. §Walker, Charles V., F.R.S., F.R.A.S. Fernside Villa, Redhill, near Reigate.
Walker, Sir Edward S. Berry Hill, Mansfield.
Walker, Francis, F.L.S., F.G.S. Rectory House, The Grove, Highgate, London, N.
Walker, Frederick John. Alltyr Odyn, Llandyssil, Carmarthen.
1866. §Walker, H. Westwood, Newport, by Dundee.
1859. ‡Walker, James. 16 Norfolk-crescent, London, W.
1855. ‡Walker, John. 1 Exchange-court, Glasgow.
1842. *Walker, John. Thorncliffe, Leamington.
1855. ‡Walker, John James, M.A. 2 Trinity College, Dublin.
*Walker, Joseph N., F.L.S. Caldeston, near Liverpool.
1866. *Walker, J. F. 16 Gilly Gate, York.
1867. *Walker, Peter G. Dundee.
1866. ‡Walker, S. D. 38 Hampden-street, Nottingham.
*Walker, Thomas. 10 York-street, Manchester.
Walker, William. 47 Northumberland-street, Edinburgh.
Wall, Rev. R. H., M.A. 6 Hume-street, Dublin.
1863. §Wallace, Alfred R., F.R.G.S. 9 Mark's-crescent, Regent's-park, London, N.W.
1859. ‡Wallace, William, Ph.D., F.C.S. Chemical Laboratory, 3 Bath-street, Glasgow.
1856. ‡Waller, Augustus V., M.D., F.R.S. Bruges.
1857. ‡Waller, Edward. Lisenderry, Aughnacloy, Ireland.
1862. ‡Wallich, George Charles, M.D., F.L.S. 11 Earls-terrace, Kensington, London, W.
Wallinger, Rev. William. Hastings.
Walmesley, Sir Joshua, Knt. Liverpool.
Walmesley, Joshua. Lord-street, Liverpool.
1862. ‡Walpole, The Right Hon. Spencer Horatio, M.A., D.C.L., M.P., F.R.S. Ealing, near London.
1857. ‡Walsh, Albert Jasper. 89 Harcourt-street, Dublin.
Walsh, John (Prussian Consul). 1 Sir John's Quay, Dublin.
1863. ‡Walters, Robert. Eldon-square, Newcastle-on-Tyne.
Walton, Thomas Todd. Mortimer House, Clifton, Bristol.
1863. §Wanklyn, James Alfred, F.R.S.E., F.C.S. London Institution, Finsbury-circus, London, E.C.
Wansey, William, F.S.A. Reform Club, London, S.W.
1857. ‡Ward, John S. Prospect-hill, Lisburn, Ireland.
1847. ‡Ward, Nathaniel Bagshaw, F.R.S., F.L.S. 14 Clapham Rise, London, S.
Ward, Rev. Richard, M.A. 12 Eaton-place, London, S.W.
1863. ‡Ward, Robert. Dean-street, Newcastle-on-Tyne.
*Ward, William Sykes, F.C.S. Denison Hall, Leeds.
Wardell, William. Chester.

Year of Election.

1867. §Warden, Alexander, J. Dundee.
1858. ‡Wardle, Thomas. Leek Brook, Leek, Staffordshire.
1865. §Waring, Dr. E. J. 28 George-street, Hanover-square, London, W.
1864. *Warner, Edwin. Higham Hall, Woodford, Essex.
1856. ‡Warner, Thomas H. Lee. Tiberton Court, Hereford.
1865. *Warren, Edward P., L.D.S. 13 Old-square, Birmingham.
Warwick, William Atkinson. Wyddrington House, Cheltenham.
1856. ‡Washbourne, Buchanan, M.D. Gloucester.
1847. ‡Waterhouse, G. R. British Museum, London, W.C.
*Waterhouse, John, F.R.S., F.G.S., F.R.A.S. Wellhead, Halifax, Yorkshire.
1854. ‡Waterhouse Nicholas. 5 Rake-lane, Liverpool.
1854. ‡Watkins, James. Bolton.
1867. §Watson, Rev. Archibald, D.D. The Manse, Dundee.
1855. ‡Watson, Ebenezer. 16 Abercromby-place, Glasgow.
1867. §Watson, Frederick Edwin. Thickthorn House, Norwich.
*Watson, Henry Hough, F.C.S. The Folds, Bolton-le-Moors.
Watson, Hewett Cottrell, F.L.S. Thames Ditton, Surrey.
Watson, James. Glasgow.
1855. ‡Watson, James, M.D. 152 St. Vincent-street, Glasgow.
1863. ‡Watson, Joseph. Bensham Grove, near Gateshead-on-Tyne.
1859. ‡Watson, J. Forbes. India Office, London, S.W.
1863. §Watson, R. S. 101 Pilgrim-street, Newcastle-on-Tyne.
1867. §Watson, Thomas D. 18 A Basinghall-street, London, E.C.
1858. ‡Watson, William. Bilton House, Harrogate.
Watson, William H.
1855. ‡Watt, George. West Regent-street, Glasgow.
1861. ‡Watts, Sir James. Abney Hall, Cheadle, near Manchester.
1846. ‡Watts, John King, F.R.G.S. St. Ives, Huntingdonshire.
1858. ‡Waud, Major E. Manston Hall, near Leeds.
Waud, Rev. S. W., M.A., F.R.A.S., F.C.P.S. Rettenden, near Wickford, Essex.
1862. §Waugh, Major-General Sir Andrew Scott, R.E., F.R.S., F.R.G.S., late Surveyor-General of India, and Superintendent of the Great Trigonometrical Survey. 7 Petersham-terrace, Queen's Gate-gardens, London, W.
1859. ‡Waugh, Edwin. Sager-street, Manchester.
*Way, J. Thomas, F.C.S., Professor of Chemistry, Royal Agricultural Society of England. 72 Victoria-street, London, S.W.
Webb, Rev. John, M.A., F.S.A. Hardwick Parsonage, Hay, South Wales.
*Webb, Rev. Thomas William, M.A., F.R.A.S. Hardwick Parsonage, Hay, South Wales.
1866. *Webb, William Frederick, F.R.G.S. Newstead Abbey, Nottingham.
1856. ‡Webster, James. Hatherley Court, Cheltenham.
1859. ‡Webster, John. 42 King-street, Aberdeen.
1858. ‡Webster, John. Broomhall Park; and St. James's-row, Sheffield.
1862. ‡Webster, John Henry, M.D. Northampton.
1864. §Webster, John. Belvoir-terrace, Sneinton, Nottingham.
Webster, Thomas, M.A., F.R.S. 2 Great George-street, London, S.W.
1853. ‡*Weddell, Thomas. Scarborough.*
1845. ‡Wedgewood, Hensleigh. 17 Cumberland-terrace, Regent's Park, London, N.W.
1854. ‡Weightinan, William Henry. Litherland, Liverpool.
1865. ‡Welch, Christopher, M.A. University Club, Pall Mall East, London, S.W.
1867. §Weldon, Walter. Park-villa, West Hill, Highgate, London, N.

Year of Election.

1850. ‡Wemyss, Alexander Watson, M.D. St. Andrews, N.B.
1850. ‡Wemyss, William. 6 Salisbury-road, Edinburgh.
Wentworth, Frederick W. T. Vernon. Wentworth Castle, near Barnsley, Yorkshire.
1864. *Were, Anthony Berwick. Whitehaven, Cumberland.
1865. ‡Wesley, William Henry. 31 Clayland-road, Clapham, London, S.
1853. ‡West, Alfred. Holderness-road, Hull.
1858. ‡West, F. H. Chapel Allerton, near Leeds.
1853. ‡West, Leonard. Summergangs Cottage, Hull.
1853. ‡West, Stephen. Hessle Grange, near Hull.
1851. ‡Western, Thomas Burch. Tattingstone House, Ipswich.
1851. *Western, Sir T. B., Bart., M.P. Felix Hall, Kelvedon, Essex.
1842. Westhead, Edward. Chorlton-on-Medlock, near Manchester.
Westhead, John. Manchester.
1842. *Westhead, Joshua Proctor. York House, Manchester.
1851. ‡Westhorpe, Stirling. Tower-street, Ipswich.
1857. *Westley, William. 24 Regent-street, London, S.W.
1863. ‡Westmacott, Percy. Whickham, Gateshead, Durham.
1860. §Weston, James Woods. Seedley House, Pendleton, Manchester.
1858. ‡ *Weston, William. Birkenhead.*
1864. §Westropp, W. H. S., M.R.I.A. 2 Idrone-terrace, Blackrock, Dublin.
1860. ‡Westwood, John O., M.A., F.L.S. Henley House, Summertown, Oxon.
Wharton, W. L., M.A. Dryburn, Durham.
1853. ‡Wheatley, E. B. Cote Wall, Merfield, Yorkshire.
Wheatstone, Sir Charles, D.C.L., F.R.S., Hon. M.R.I.A., Professor of Experimental Philosophy in King's College, London. 19 Park-crescent, Regent's Park, London, N.W.
1866. §Wheatstone, Charles C. 19 Park-crescent, Regent's Park, London.
1847. ‡Wheeler, Edmund, F.R.A.S. 48 Tollington-road, Holloway, London, N.
1853. ‡Whitaker, Charles J. P. Milton Hill, near Hull.
1859. *Whitaker, William, B.A., F.G.S. Geological Survey Office, 28 Jermyn-street, London, S.W.
1866. §White, Charles, F.R.G.S. Barnesfield House, near Dartford, Kent.
1864. ‡White, Edmund. New Bond-street, Bath.
White, John. 80 Wilson-street, Glasgow.
1859. ‡White, John Forbes. 16 Bon Accord-square, Aberdeen.
1865. §White, Joseph. Regent's-street, Nottingham.
1859. ‡White, Thomas Henry. Tandragee, Ireland.
1861. ‡Whitehead, James, M.D. 87 Mosley-street, Manchester.
1854. ‡Whitehead, James W. 15 Duke-street, Edge-hill, Liverpool.
1858. ‡Whitehead, J. H. Southsyde, Saddleworth.
1861. *Whitehead, J. B. Oakley-terrace, Rawtenstall, Manchester.
1861. *Whitehead, Peter Ormerod. Belmont, Rawtenstall, Manchester.
1855. * *Whitehouse, Wildman.*
Whitehouse, William. 10 Queen-street, Rhyl.
*Whiteside, James, M.A., Lord Chief Justice of Ireland. 2 Mountjoy-square, Dublin.
1866. §Whitfield, Samuel. Golden Hillock, Small Heath, Birmingham.
1861. ‡Whitford, J. Grecian-terrace, Harrington, Cumberland.
1852. ‡Whitla, Valentine. Beneden, Belfast.
Whitley, Rev. Charles Thomas, M.A., F.R.A.S., Reader in Natural Philosophy in the University of Durham. Bedlington, Morpeth.
1865. ‡Whittern, James Sibley. Wyken Colliery, Coventry.
1857. *Whitty, John Irwine, C.E., M.A., D.C.L., LL.D., Ricketstown Hall, Carlow.
1863. *Whitwell, Thomas. Stockton-on-Tees.

Year of Election.

*Whitworth, Joseph, LL.D., F.R.S. The Firs, Manchester; and Stancliffe Hall, Derbyshire.
1857. ‡Widdup, —. Penzance; and Kilburn, Co. Wexford.
1865. ‡Wiggin, Henry. Metchley Grange, Harbourne, Birmingham.
1863. ‡ *Wigham, John. Dublin.*
1852. ‡Wigham, Robert. Norwich.
1854. §Wight, Robert, M.D., F.R.S., F.L.S. Grazeley Lodge, Reading.
1860. ‡Wilde, Henry. 2 St. Ann's-place, Manchester.
1852. ‡Wilde, Sir William Robert, M.D., M.R.I.A. 1 Merrion-square North, Dublin.
Wilderspin, Samuel. Wakefield.
1855. ‡Wilkie, John. 46 George-square, Glasgow.
1861. *Wilkinson, Eason, M.D. Greenheys, Manchester.
1857. ‡Wilkinson, George. Monkstown, Ireland.
1859. ‡Wilkinson, Robert. Totteridge Park, Hertfordshire.
Willan, William.
*Willert, Paul Ferdinand. Manchester.
1859. ‡Willet, John, C.E. 35 Albyn-place, Aberdeen.
*Williams, Caleb, M.D. Micklegate, York.
Williams, Charles James B., M.D., F.R.S., Professor of Medicine in University College, London. 49 Upper Brook-street, Grosvenor-square, London, W.
1861. *Williams, Charles Theodore, B.A. 49 Upper Brook-street, London.
1864. *Williams, Frederick M., M.P., F.G.S. Goonvrea, Perranarworthal, Cornwall.
1861. *Williams, Harry Samuel. 49 Upper Brook-street, Grosvenor-square, London, W.
1857. ‡Williams, Rev. James. Llanfairinghornwy, Holyhead.
Williams, Richard. 38 Dame-street, Dublin.
Williams, Robert, M.A. Bridehead, Dorset.
1861. ‡Williams, R. Price. 22 Ardwick Green, Manchester.
Williams, Walter. St. Alban's House, Edgbaston, Birmingham.
*Williams, William. Highbury-crescent, London, N.
1865. ‡Williams, William M. The Celyn, Caergwele, near Wrexham.
1850. *Williamson, Alexander William, Ph.D., F.R.S., F.C.S., Professor of Chemistry, and of Practical Chemistry, University College, London. 12 Fellows-road, Haverstock-hill, London, N.W.
1857. ‡Williamson, Benjamin. Trinity College, Dublin.
1863. ‡Williamson, John. South Shields.
*Williamson, Rev. William, B.D. Datchworth, Welwyn, Hertfordshire.
Williamson, W. C. Manchester.
Willis, Rev. Robert, M.A., F.R.S., Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge. 23 York-terrace, Regent's Park, London, N.W.; and Cambridge.
1865. *Willmott, Henry. Mona House, Handsworth, Birmingham.
1857. ‡Willock, Rev. W. N., D.D. Cleenish, Enniskillen, Ireland.
1859. *Wills, Alfred. 4 Harcourt-buildings, Inner Temple, London, E.C.
1865. ‡Wills, Arthur W. Edgbaston, Birmingham.
Wills, W. R. Edgbaston, Birmingham.
*Wilson, Alexander, F.R.S. 34 Bryanston-square, London, W.
1859. §Wilson, Alexander Stephen, C.E. North Kinmundy, Summerhill, by Aberdeen.
1850. ‡Wilson, Dr. Daniel. Toronto, Upper Canada.
1863. ‡Wilson, Frederic R. Alnwick, Northumberland.
1847. *Wilson, F. Leamington.
1863. §Wilson, George. Hawick.
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